The British Columbia High Technology Sector

Input Indicators Report

The 1990s

A joint project of BC Stats and the
BC Information, Science and Technology Agency

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Executive Summary

This report tracks the evolution of forty-two indicators of the climate for development of the high technology sector in the province of British Columbia. The indicators, which might be termed "input" measures, are chosen for their relevance and general acceptance, as well as their availability on an ongoing basis.

Indicators of the success, or "outputs" of the high technology sector, are covered by a companion report, the *Profile of the British Columbia High Technology Sector.*[1] The *Profile* contains information on high technology Gross Domestic Product (GDP), employment, wages and salaries, revenues, establishments, and exports and imports.

The picture of British Columbia that emerges from the input indicators is varied. In some areas, British Columbia is strong when compared to other provinces, and has shown strong growth over the past decade. In other areas, performance has lagged. In this way the detailed indicators offer concrete guidance about potential government policies and industry growth strategies.

The forty-two indicators covered in this report normally span available data for the 1990s, and include the provinces of Alberta, Ontario, and Quebec, in addition to British Columbia. International statistics have not been included at this stage, because of the difficulty of making valid comparisons of indicators collected with varying definitions and against very different backdrops of social and economic organization.

The indicators presented here cover key aspects of the educational, business, government, external, and labour sectors from the point of view of their impact on high technology firms.

In the **educational sector**, British Columbia shows evidence of strong attainment in the general population. However, there is a very significant deficiency with respect to the training of new graduates in engineering and computer science. In engineering, for example, graduates in relation to population are fewer than half of those in Ontario and Alberta. Similarly, higher education research and development is significantly low by Canadian standards, in relation to GDP.

In the **business sector**, compared to other Canadian provinces, British Columbia returns average or below average ratings in all of the business stimulus indicators. However, many have long term upward trends and good performance in the latest year. Exceptions are venture capital and business sector research and development. British Columbia business has been unable to attract much more than ten percent of Canadian venture capital funding (although this is roughly in line with our population size). Business sector performance of research and development has also lagged. In 1997, the ratio of R&D performance by business to provincial GDP was over twice as large in Quebec and Ontario as in British Columbia.

[1] Available at http://www.bcstats.gov.bc.ca/DATA/BUS_STAT/hi_tech.htm

In the **government sector**, British Columbia's tax regime is approximately on a par with other provinces. However, the federal Scientific Research and Experimental Development (SR&ED) tax credit program has not benefited this province in proportion to the size of its economy. Also, direct government (federal and provincial) performance of research and development in relation to GDP is about half the Canadian average.

In the **external sector**, the British Columbia economy is part of a world system that is a source of information, skilled labour, machinery and equipment and other material inputs, as well as markets for locally-produced products. Conversely, British Columbia may lose skilled labour to other jurisdictions or face competition from foreign producers.

Canada, and with it British Columbia, benefits from a large number of well-trained immigrants. The number of such immigrants has increased greatly in recent years, and their level of schooling has increased as well. In relation to its population size, British Columbia is on a par with other provinces in attracting skilled foreigners. As for immigration from other provinces, British Columbia is likely to gain educated and trained workers when there is immigration from other provinces, but in recent years, British Columbia has been losing people to other provinces.

In the **labour sector**, unemployment rates among workers in the natural and applied sciences are well under half of those in the economy overall. Further, these unemployment rates have been falling quite consistently since the early 1990s. Corresponding wage rates in the high technology sector are significantly above those in the other sectors, for workers in high knowledge as well as other occupations required in the sector. Overall, BC's high technology employment grew rapidly in the 1990s, but lagged behind the high technology provinces as a percentage of overall employment. In 1995, BC's research workforce was the smallest per capita among the high technology provinces.

As an aid to summarizing the wealth of available information, up, down, and horizontal arrows (↑,↓,→) have been used to show whether an indicator has risen, dropped, or remained substantially unchanged over time (see FIGURE 1). The assessment is made with regard to the trend over the span of time for which the indicator is available, and for the latest period. A final comparison is made of where British Columbia stands in comparison to the Canadian average for the indicator. British Columbia is characterized as being above, below, or substantially equal to this average. **Important Note:** The fact that an indicator may have been rising, or is labeled "above average" in relation to other provinces does not necessarily indicate an advantage for the BC high technology sector. This depends on how each indicator is constructed. For example, above average taxes would normally be viewed as a negative indicator from the point of view of the high technology sector.

FIGURE 1: Quick Summary Table of All 42 Indicators

EDUCATION SECTOR INDICATORS	Trend	Latest Year	Compared to Other Provinces
1. High school diplomas per capita	↑	↑	above average
2. Postsecondary credentials per capita	↑	↑	above average
3. 16-year-old achievement rank: mathematics content	→	→	above average
4. 16-year-old achievement rank: mathematics problems	↓	↓	above average
5. 16-year-old achievement rank: science	n/a	n/a	average
6. Annual BSc graduates in engineering per capita	↑	↓	below average
7. Annual BSc graduates in computer science per capita	↑	↓	below average
8. Annual scientific publications per capita	↑	↑	below average
9. Rate of international collaboration on publications	n/a	n/a	above average
10. Rate of intersectoral collaboration on publications	n/a	n/a	average
11. Percentage of households with computers	n/a	n/a	above average
12. Percentage of households using the internet	n/a	n/a	above average
13. Gross income per technology license at universities	→	→	below average
14. US patents issued to top two universities	→	↑	above average
15. Higher education performance of R&D to GDP ratio	→	→	below average
BUSINESS SECTOR INDICATORS			
16. Patents per capita	↓	↑	below average
17. Patent applications per capita	↑	↑	below average
18. Entries and exits into the high technology sector	↑	↑	n/a
19. # of establishments in the high technology sector	↑	↑	n/a
20. # of gazelles (high growth companies)	↑	↑	n/a
21. Venture capital	↑	↓	average
22. Venture capital: share of Canadian total	→	↓	average
23. Venture capital per capita	↑	↓	average
24. Business performance of R&D to GDP ratio	→	→	below average
GOVERNMENT SECTOR INDICATORS			
25. Tax index for $80,000 income	↓	↓	average
26. Small business tax rate	↓	↓	below average
27. Corporate tax rate	→	→	above average
28. SR&ED tax credits per capita	↑	↑	below average
29. SR&ED tax credits per capita (small firms)	↑	↓	above average
30. Government performance of R&D to GDP ratio	↓	↓	below average
31. Gross expenditure on R&D (GERD) to GDP ratio	→	→	below average
EXTERNAL SECTOR INDICATORS			
32. Number of immigrants with higher education	↑	↑	average
33. Education level of immigrants	↑	→	average
34. Education and occupation of interprovincial migrants	n/a	n/a	above average
35. Net interprovincial migration	↓	↑	below average
36. High technology imports	↑	↑	n/a
LABOUR SECTOR INDICATORS			
37. Unemployment rate for natural and applied sciences	↓	↓	average
38. Ratio of unemployment rate for natural and applied sciences to the unemployment rate for all occupations	↓	↓	average
39. Income premium in the high technology occupations	→	n/a	below average
40. Income premium in the high technology industries	↓	n/a	below average
41. High technology employment	↑	↑	below average
42. Research personnel per capita	n/a	n/a	below average

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Introduction

Although industry has been knowledge and technology-based through history, information as a driver of economic growth has grown dramatically in importance in the last quarter century. Economies are now much more dependent on the production, dissemination, and use of knowledge. In turn, output and employment are expanding most rapidly in high technology industries, which are those industries whose primary input is knowledge.

This document, *British Columbia High Technology Indicators: the 1990s*, is the first in a projected annual series monitoring the high technology sector from the input side. Its objective is to measure and analyze the production and application of knowledge, and the climate, institutions, and funding arrangements that make this knowledge available for development of the BC high technology sector. It is to be used hand-in-hand with the outputs report, the *Profile of the British Columbia High Technology Sector: 2000 Edition*,[2] to give an overall indication of where BC's high technology sector has been and where it might be heading.

Background

Since 1994, BC STATS, in conjunction with the Information, Science & Technology Agency (ISTA), has been producing the *Profile of the British Columbia High Technology Sector* annually. The *Profile* gives measures of Gross Domestic Product (GDP), employment, wages and salaries, revenues, establishments, and exports and imports—what might be called the outputs of the high technology sector. By maintaining a consistent methodology from year to year, the *Profile* gives an excellent indication of the growth of the BC high technology industry.

While there is obvious value in monitoring the "output" of the high technology sector, informed policy-making requires information about the processes that give rise to that output. In fact, the high technology sector and the infrastructure network that surrounds it is a complex system with many players and interactions. Understanding this system, as with any system, is a matter of identifying the various parts, and collecting information that shows how these parts behave and interact over time.

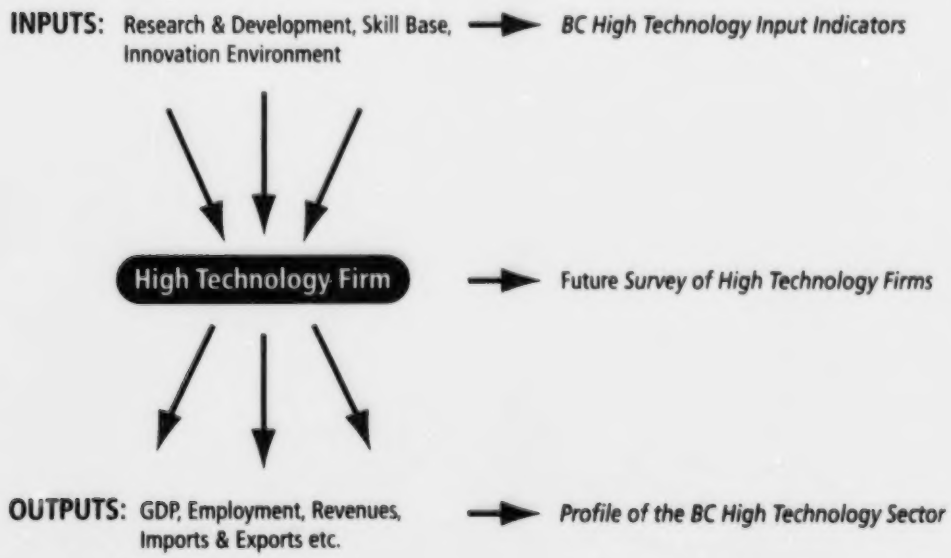
[2] Available at http://www.bcstats.gov.bc.ca/DATA/BUS_STAT/hi_tech.htm

Information on the high technology "system" will help to show the best ways to foster growth in the sector. This will almost certainly include assistance to parts of the system that are only indirectly linked to actual production (and often removed in time). For example, improvements to the secondary school system may seem different in kind from output subsidies or tax cuts for high technology firms, but both schools and firms may be components of the same system. Good information will help to confirm such suppositions, and most importantly, to identify the strength of any anticipated relationships.

In BC STATS' model of the high technology sector (see "Modeling the High Technology Sector," below), the **firm** is the centre of the system of high technology production. The firm receives inputs, in the form of labour, physical and financial capital, raw materials and parts, and knowledge. Knowledge may be embodied in labour (human capital) or other inputs, or it may come in the form of patents and copyrights, books and electronic information, etc. Through its internal operations, the firm then produces outputs. These outputs are products and services, and (in some views) also include employment and other benefits to society.

This firm-centred view underlies BC STATS' publication strategy for high technology sector information, as shown below in FIGURE 2.

FIGURE 2: BC STATS' Products Monitoring the High Technology Sector


INPUTS: Research & Development, Skill Base, Innovation Environment
BC High Technology Input Indicators
High Technology Firm
Future Survey of High Technology Firms
OUTPUTS: GDP, Employment, Revenues, Imports & Exports etc.
Profile of the BC High Technology Sector

What is an Indicator?

The concept of indicators is well understood in the operation of machines. For instance, the dashboard of a car has many indicators. The speedometer measures the main output, which is forward motion. However, gauges such as oil pressure and water temperature assess how well the engine is working as a system. They predict the engine's future performance, and may suggest the need for specific adjustments.

When we want to predict the future, in terms of the economy, we need to examine the chain of events that leads to the production of specific outputs, and develop indicators for those steps in the chain judged to be most important. When we want to predict the future in terms of the high technology sector, we similarly need to develop a model of what drives growth in the sector, and then obtain indicators for each component of the model.

In selecting indicators, consideration must be given not only to their place in a growth model of the high technology sector, but also to their accuracy and availability. Indicators should meet other tests as well. In the annual (since 1997) *Index of the Massachusetts Innovation Economy*,[3] all potential indicators are subject to a set of five criteria. The indicators selected for inclusion in the report are:

- Derived from objective and reliable data sources,
- Statistically measurable on an ongoing basis,
- Bellwethers that reflect the fundamentals of economic vitality,
- Understood and accepted by the community, and are
- Measurements of conditions in which there is an active public interest.

These criteria help ensure that the indicators become relevant to politicians and citizens as well as to statisticians, and have been adopted for this report as well.

How is Research Progressing in this Field?

Detailed and generally accepted models for high technology sector growth do not exist at present. However, there has been loose agreement on some of the most important factors. One of the first of these factors to be explored was "research and development" spending. At the international level, the Organization for Economic Cooperation and Development (OECD), of which Canada is a member nation, took the lead with the *Frascati Manual: Proposed Standard Practice for Surveys of Research and Experimental Development* (1963). Meeting in Frascati, Italy, national experts of research

[3] Collaborative Economics and Massachusetts Technology Collaborative, Index of the Massachusetts Innovation Economy, 1999. Available at http://www.mtpc.org/research/indica99.htm

and development statistics recognized the need for consistent, comparable international measures. Their proposal became the international standard.

In 1995, the Science and Technology Agency of Japan published *Science and Technology Indicators: 1994—A Systematic Analysis of Science & Technology Activities in Japan*, an update and revision of a similar document published in 1991. This comprehensive project was heavily focused on international comparisons between Japan and other nations, on the one hand comparing ratios of science and technology expenditures to Gross National Product for several leading science and technology countries, while on the other comparing the number of museums in Japan to the number in other countries. The critical focus, however, was on comparisons of research and development expenditures and effort between nations.

In 1997, the Massachusetts Technology Collaborative, a joint effort of government, industry and academia, produced the first of its annual publications, *Index of the Massachusetts Innovation Economy* which presented 33 indicators (a mixture of both input and output indicators). However, these indicators are focused more on the intangible innovation economy which is "based on a dynamic conceptual framework that links resources to economic results through an innovation process." The index annually tracks the benchmark performance (indicators) of nine key industry clusters for six leading technology states throughout the US. The 1999 version of the *Index* covers 30 separate indicators.

A similar effort has been produced by the Progressive Policy Institute (PPI) in the United States, which is responsible for the "New Economy Index." PPI offers thirty-nine indicators at the national level, and seventeen for each of fifty states.[4]

In 1998 Statistics Canada published *Science and Technology Activities and Impacts: A framework for a statistical information system* as well as *A Five-Year Strategic Plan for the Development of an Information System for Science and Technology*. These documents did not themselves contain any indicators but rather proposed a framework and strategy for the collection of science and technology indicators. However, Statistics Canada also stated "There is little underlying theory of how science and technology develops and interacts with other activities in different institutions. There are some procedural measures, many unsubstantiated beliefs and myths, and there are major information gaps." These caveats from Statistics Canada show that there is still much work to be done in this field.

[4] Available at http://www.neweconomyindex.org/states/

In 1998, BC STATS, ISTA, and the Science Council of BC began a collaboration to devise a model of the BC high technology sector, with an associated set of indicators. This resulted in two working papers. The first reviewed definitions of the high technology sector and models of the innovation economy in other jurisdictions, while the second proposed a model for use in BC, together with a large number of potential indicators for that model.[5] Subsequently BC STATS has simplified the model and prepared a corresponding shorter list of indicators. The simplified model and indicators form the basis for this publication.

Modeling the High Technology Sector

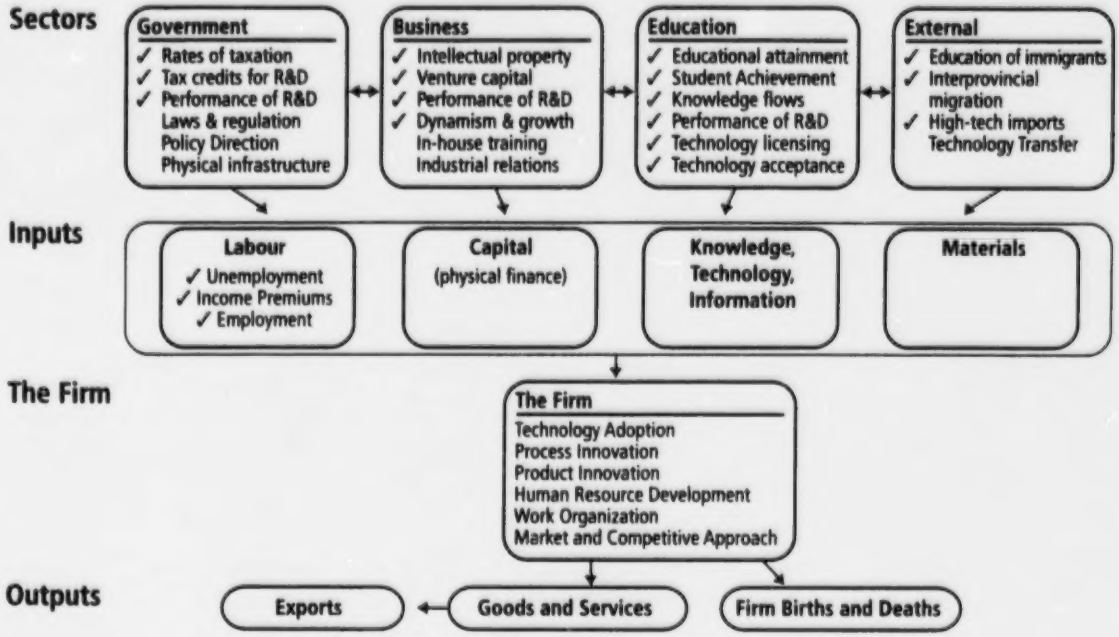
The traditional model of economic production focuses on land, labour and capital, which are the "factors of production" or inputs into the production process. These factors are transformed by firms, other organizations, or individuals into valued goods and services. GDP is the main measure of that value and is the most common statistic used to describe the production of economic sectors. This traditional model can be thought of as an input/output view of the economy. The inputs are obtained from a variety of sources and enter a production process, resulting in outputs.[6]

The advent of the "information economy" has added a new dimension to traditional economic production, and some efforts to describe it seem quite new as well. However, the input/output view can readily be adapted to the information economy. In FIGURE 3, the firm is at the centre of the productive system. As in the traditional model, the firm receives inputs, however knowledge, technology, and information are distinguished as a unique category. This can include patents and copyrights, software, information on production methods, etc. In addition, it is recognized that the other factors, labour, capital, and materials each have critical and increasing quantities of knowledge embodied in them.

[5] Koebberling, Uschi and Veneranda Detmers, "A Model of the BC High Technology Sector: Description of Factors and Linkages Affecting the Growth of the High Technology Sector in the Context of an Innovation Economy," Science Council of BC, April 1999.

[6] This is also referred to as the neoclassical model. See Lipsey, Richard G. and Kenneth Carlaw, "A Structuralist Assessment of Technology Policies—Taking Schumpeter Seriously on Policy," Working Paper # 25, Industry Canada, Research Publications Program, October 1998. Available at http://www.strategis.ic.gc.ca

FIGURE 3: Model of the High Technology Sector



The diagram then looks beyond the production inputs, to analyze their sources (the top row of boxes). For example, skilled labour may come from training courses in educational institutions, from in-house training, or from other provinces or countries. The sources for the inputs have been categorized as four "sectors." Within each sector, particular areas that bear on the production inputs are identified. These areas are the ones for which indicator variables have been sought out. The areas listed in bold, and ticked, are the ones for which data is available and has been collected by BC STATS.

While the indicator variables have normally been sought out at the level of the source sectors, certain labour indicators, such as the unemployment rate, are not attributable to a single source sector. Such indicators have been grouped in a separate "labour" section.

Once the inputs are obtained by the firm, they are transformed in a way that depends on the firm's many characteristics. Some of the characteristics of most importance for high technology firms are listed within the FIRM box in the diagram.[7]

[7] For an in-depth study of uses of knowledge within high technology firms, see Schuetze, Hans, "Innovation, Skills, and Learning: A Study of Knowledge and Human Resources Management in Small and Medium Sized Enterprises in British Columbia," Centre for Policy Studies in Education, University of British Columbia, March 1998.

Finally, the firm produces and sells goods and services, some of which are consumed locally, while the remainder are exported. This is depicted in the bottom row. It should be recognized that even with a simplified model such as the one set out here, it is possible to imagine a large number of interactions. That is, almost every box or element within the boxes could be joined by an arrow to every other box or element. In turn, a complete statistical system based on the model would track the flows of people, dollars, or information along each of the pathways (arrows). Such a comprehensive approach is neither practical, nor would it in the end necessarily lead to greater understanding and better policy. However, statistics are available on a significant number of the interactions, providing a strong database for future research.

Comparison with Other Jurisdictions

Wherever possible the indicators selected for this publication have been presented for the provinces of Alberta, Ontario, and Quebec. Comparisons to other provinces show the range of what is possible, or what has been achieved, within the Canadian context. The three provinces chosen have the largest general economies, and they are the ones with the most extensive high technology sectors. Based on 1999 employment, these shares range from 4.2% to 4.7% of overall activity. The BC share for the same year was just over 3.5%, while the average for the rest of Canada was 1.9%. It should be noted that the provinces used for comparative purposes do have significant variation in terms of high technology growth. For the ten years leading to 1999, Ontario posted high-tech employment compound growth of just 2.3%, while Alberta posted 6.3%, Quebec 3.9%, and BC 7.9%. Growth in the rest of Canada was 3.8%.

Another advantage of the comparisons to other provinces is that the basis for tabulating the statistics is consistent. Comparisons between jurisdictions where definitions, methods of collection, laws, and economic infrastructure vary are often of little or no use. That is why international comparisons, such as comparisons to US states, have not been included in this edition. Very careful study is needed before such comparisons can be used with confidence. Nevertheless, some international comparisons are a goal for future editions.

The Quick Summary Reports

The forty-two indicators selected for this publication represent only a fraction of the information base that is available about the high technology sector. However, even forty-two indicators measured over time and across provinces pose a challenge to

readers looking for an overview of the current situation and an indication of which areas warrant further study. To meet this challenge, this report is first divided according to the four "sectors" outlined in the model diagram (FIGURE 3). One of the "inputs," labour, is also covered in a separate section. Each of the five resulting sections covers a number of individual indicators. These indicators are listed on the first page of the section, in a quick summary. The summary makes use of up, down, and horizontal arrows (↑, ↓, →) to show whether the indicator has risen, dropped, or remained substantially unchanged. The assessment is made with regard to the trend over the span of time for which the indicator is available, and for the latest period. A final comparison is made of where British Columbia stands in comparison to the Canadian average for the indicator. British Columbia is characterized as being above, below, or substantially equal to this average.

Since the arrow indicators show only the direction of change, the summary report gives no indication of the size of changes, or their pattern over time. This information is found in the graphs and text included in each section.

It is immediately apparent that some indicators will be up while others are down, and that these movements are of differing intensity. Forming an overall assessment of the state of the high technology sector involves the evaluation of the significance of each indicator (weighting each indicator) and combining this with the strength of recent movements, trends, and comparisons to other provinces. This report provides tools and information that can help with this assessment, but no attempt is made to combine the indicators into a single measure.

Educational Indicators

The education sector is identified in the model (FIGURE 3) as a provider of "inputs" to high technology firms. This happens through providing individuals with skills and knowledge that are required for product development and production, and with the commercialization of research that is performed in the educational sector. The indicators listed below are measures of this dual role. Many are presented on a per capita or per GDP basis to allow meaningful comparison with other provinces.

British Columbia shows evidence of strong educational attainment in the general population. However, there is a very significant deficiency with respect to the training of new graduates in engineering and computer science. In engineering, for example, graduates in relation to population are fewer than half of those in Ontario and Alberta. Similarly, higher education research and development is significantly low by Canadian standards, in relation to GDP.

FIGURE 4: Quick Summary Report of Indicators for the Education Sector

INDICATOR	Trend	Latest Year	Relative to Other Provinces
1. High school diplomas per capita	↑	↑	above average
2. Post-secondary credentials per capita	↑	↑	above average
3. 16-year-old achievement rank: mathematics content	→	→	above average
4. 16-year-old achievement rank: mathematics problems	↓	↓	above average
5. 16-year-old achievement rank: science	n/a	n/a	average
6. Annual BSc graduates in engineering per capita	↑	↓	below average
7. Annual BSc graduates in computer science per capita	↑	↓	below average
8. Annual scientific publications per capita	↑	↑	below average
9. Rate of international collaboration on publications	n/a	n/a	above average
10. Rate of intersectoral collaboration on publications	n/a	n/a	average
11. Percentage of households with computers	n/a	n/a	above average
12. Percentage of households using the internet	n/a	n/a	above average
13. Gross income per technology license at universities	→	→	below average
14. US patents issued to top two universities	→	↑	above average
15. Higher education performance of R&D to GDP ratio	→	→	below average

Educational Attainment

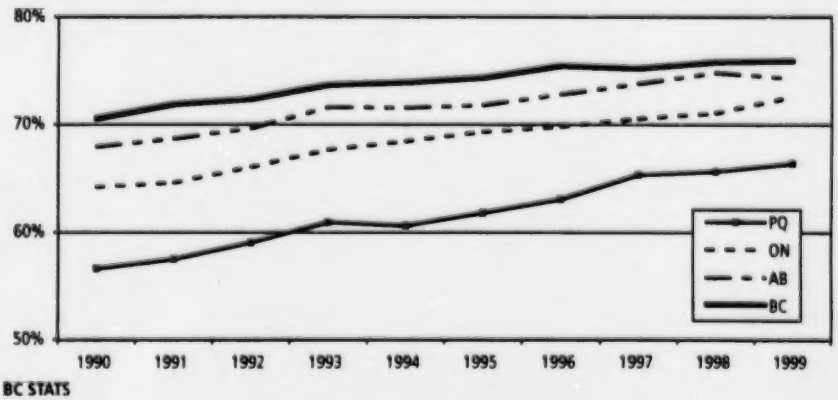
Two indicators of educational attainment, the percentage of the population older than 15 with a high school diploma, and the percentage of the population older than 15 with postsecondary credentials, have both been showing a steady increase across Canada throughout the 1990s. More people are completing high school and continuing their education, obtaining postsecondary credentials.

Why are these indicators important?

These indicators are considered important to the development of the high technology sector because higher levels of educational attainment suggest a more knowledgeable population base that is better able to understand and participate in the complexity of the high technology economy. Also, higher levels of educational attainment provide a broader, more highly-developed skill base which high technology firms can draw upon.

BC leads the high technology provinces with the highest percentage of its population older than 15 with a high school diploma. However, the gap between BC and the other high technology provinces has narrowed over the 1990s. In 1990, BC's percentage of the population 15 years old and older with a high school diploma was seven percentage points higher than Ontario, and three percentage points higher than Alberta; in 1999, it was three percentage points higher than Ontario and two percentage points higher than Alberta.

FIGURE 5: Percentage of the Population 15+ with High School Diploma



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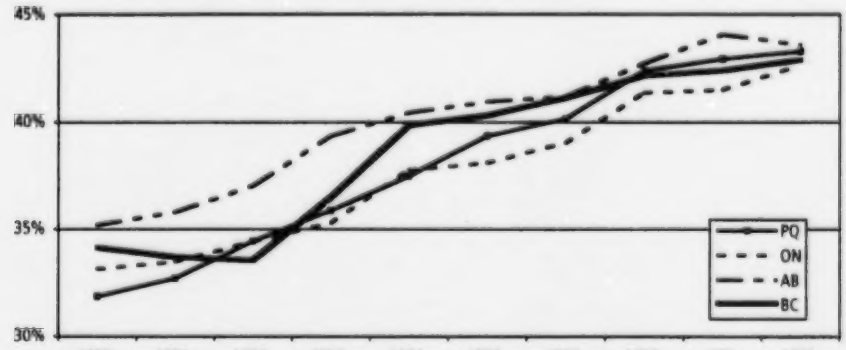
Throughout the 1990s, BC trailed Alberta in the percentage of the population 15 years old and older with some form of postsecondary credentials. Although the gap widened in 1992 and actually disappeared in 1996, it was the same size in 1999 as in 1990. However, the province of Quebec, which began the 1990s lower than BC, passed BC in 1997.

FIGURE 6: Percentage of the Population 15+ with Postsecondary Credentials



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Postsecondary credentials is a measure of those who attended a public or private institution after high school and obtained a certificate, diploma or degree. Those who have enrolled and quit or who have not yet completed a program are not included. This measure includes trade and vocational certificates and apprenticeship programs as well as college and university certificates, diplomas and degrees.

16-Year-Old Achievement on Canadian Standardized Tests

Since the inception of the School Achievement Indicators Project, BC has consistently ranked in the top five provinces in terms of the percentage of 16-year-olds demonstrating excellence on Canada-wide standardized mathematics and science tests. Alberta has ranked consistently in the top two.

Why are these indicators important?

Standardized testing in mathematics and science offers a comparable measure nation-wide for the demonstrated skills and knowledge of students of a given age. The School Achievement Indicators Project, founded in 1993, is a nation-wide project of the Council of Ministers of Education, Canada. Completed tests are graded into five levels of demonstrated competence. The rankings presented here are based on the percentage of students who achieved at level 4 and above (the upper end of achievement). This indicates the percentage with higher than average abilities in math and science.

Mathematics content tests are to assess student skills level at:

- numbers and operations,
- algebra and functions,
- measurement and geometry, and
- data management and statistics.

In 1997, BC ranked third nationwide behind Alberta and Quebec. Nearly 13% of BC students achieved level 4 or above versus 16% for Alberta and nearly 22% for Quebec.

FIGURE 7: Canada-wide Rank of 16-Year-Old Achievement in Mathematics Content, 1997 (1993)

PROVINCE	1997 (1993) RANK
Quebec	1 (2)
Alberta	2 (1)
British Columbia	3 (3)
Ontario	5 (5)

Mathematics problem-solving tests are to assess student skills level at:

- formulating problems,
- applying a variety of strategies to solving problems,
- producing solutions to problems, and
- verifying that particular solutions are valid.

In 1997, BC and Ontario ranked fourth nationwide behind Saskatchewan, Alberta and Quebec. Ten percent (10%) of BC students achieved level 4 or above versus over 14% for Alberta and over 18% for Quebec.

FIGURE 8: Canada-wide Rank of 16-Year-Old Achievement in Mathematics Problem-Solving, 1997 (1993)

PROVINCE	1997 (1993) RANK
Quebec	1 (2)
Alberta	2 (1)
British Columbia	4 (3)
Ontario	4 (5)

The purpose of the science written assessment is to assess students':

- knowledge of the concepts of science,
- understanding of the relationship of science to technology and societal issues,
- conceptual knowledge,
- procedural knowledge, and
- ability to use science to solve problems.

In 1996, BC ranked fifth nationwide; Alberta ranked first. Nearly 24% of BC students achieved level 4 or above versus over 42% for Alberta.

FIGURE 9: Canada-wide Rank of 16-Year-Old Achievement in Science, 1996

PROVINCE	1996 RANK
Alberta	1
British Columbia	5
Ontario	6
Quebec	8

The second science assessment was held in 1999 but results were not available at the time of this writing.

Engineering and Computer Science Degrees

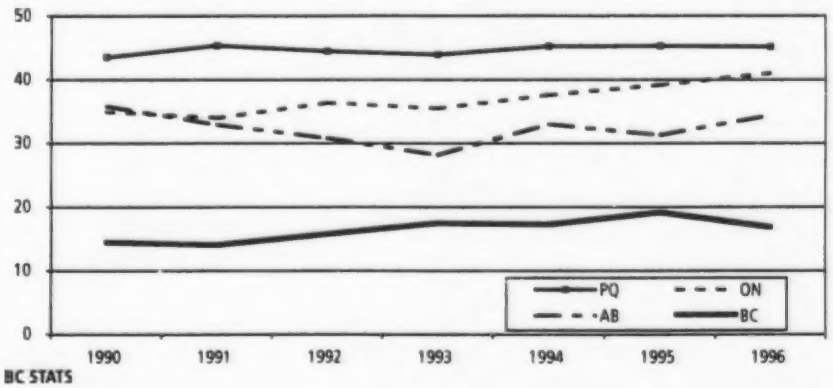
An indicator of the presence of engineers and computer scientists in a high technology economy is the number graduating annually from universities with Bachelor degrees in these respective areas per 100,000 persons age 15 and older. Between 1990 and 1996, BC has graduated far fewer Bachelors of Science in Engineering per 100,000 persons age 15 and older than the other leading high technology provinces. The numbers of Bachelors of Science in Computer Science graduated per 100,000 persons age 15 and older was low over the same period compared to the Canadian average.

Why are these indicators important?

Engineers and computer scientists are thought to be the driving force behind the high technology sector. Engineers and computer scientists are those who are most engaged in the design of new software and hardware, as well as those who are finding innovative ways to integrate computers and software into other products.

Between 1990 and 1996, BC graduated far fewer Bachelors of Science in Engineering per 100,000 persons age 15 and older than the other leading high technology provinces. The number of engineers graduating in BC peaked in 1995. In this measure, BC trails the country by a significant amount. The next closest is Newfoundland, which in 1996 graduated 27.6 engineers per 100,000 persons age 15 and older.

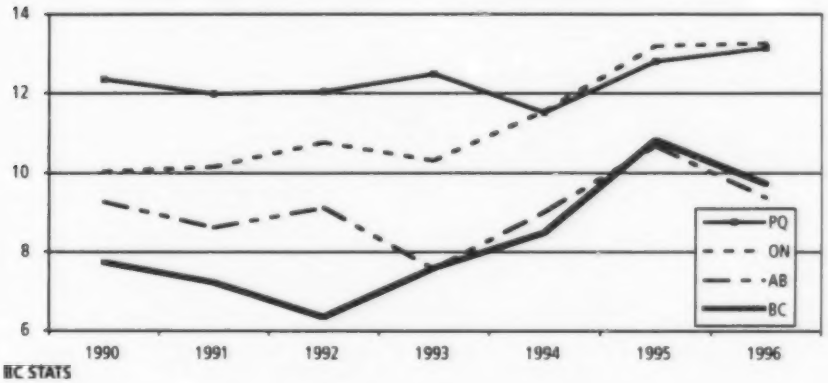
FIGURE 10: BSc in Engineering per 100,000 persons age 15 and older



BC STATS

In terms of Computer Science Bachelor degrees, BC showed dramatic improvement from 1992 through 1995. However, in 1996, the most recent year for which data is available, the number of graduates in computer science per 100,000 persons age 15 and older declined. Although Alberta started out considerably ahead of BC in this category, in 1996 BC passed Alberta although both provinces showed a decline that year. BC still lags both Ontario and Quebec in this category.

FIGURE 11: BSc in Computer Science per 100,000 persons age 15 and older



BC STATS

Bibliometrics

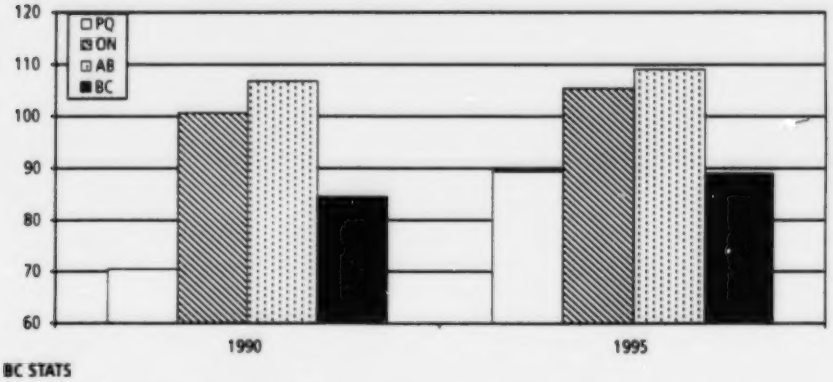
In both years for which data is available in the 1990s, BC published far fewer publications per 100,000 persons than Alberta and Ontario, but more than the Canadian average. BC led Canada in 1995 with the highest overall rate of international collaboration on scientific papers but trailed Ontario on the rate of intersectoral collaboration (i.e. between universities, businesses, hospitals and government).

Why are these indicators important?

As described in the paper "Knowledge Flows in Canada as Measured by Bibliometrics,"[8] "Bibliometric indicators of science and technology provide an important contribution to the understanding of the production of science and technology, as measured by the production of scientific publications, and of knowledge flows within the science and technology system....Bibliometric indicators can shed light on science and technology production and knowledge flow at the international, national, provincial, sub-regional, municipal and institutional levels and thus constitute a critical component of the information system on science and technology for Canada." Measures of international and intersectoral collaboration illuminate how new ideas are developed and shared.

In 1995, BC ranked seventh overall in Canada in the number of publications per 100,000 population while Alberta and Ontario ranked first and second respectively.

FIGURE 12: Publications per 100,000 Population

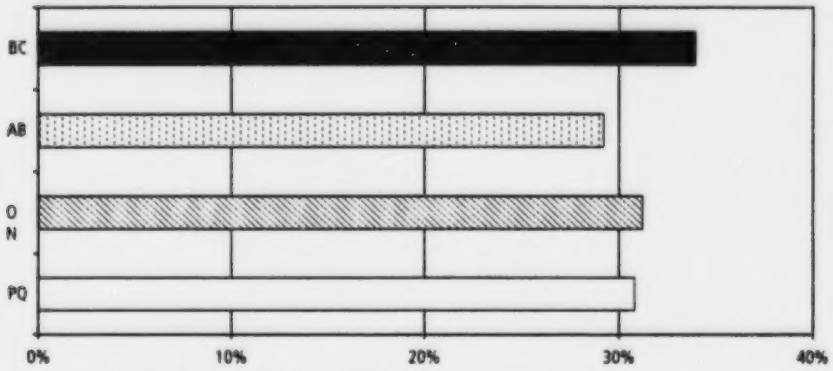


BC STATS

[8] Godin, Benoit, Gingras, Yves and Louis Davignon of Observatoire des Sciences et des Technologies (CIRST), "Knowledge Flows in Canada as Measured by Bibliometrics," Statistics Canada Working Paper, 1998.

In 1995, BC had the highest rate of international collaboration on scientific papers, while Ontario, Quebec and Alberta ranked third, fourth and fifth, respectively.

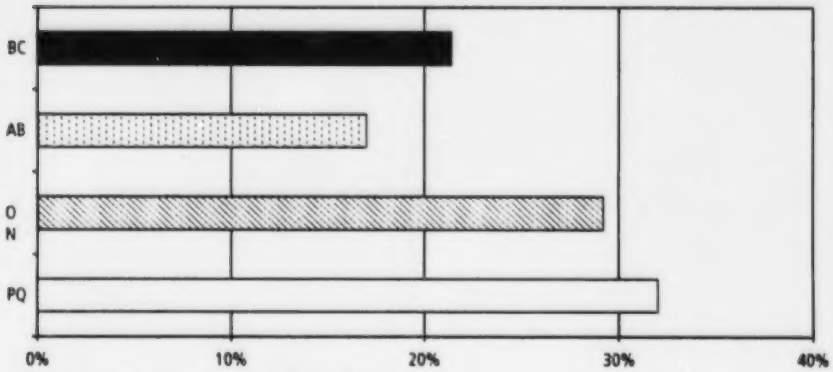
FIGURE 13: Rate of International Collaboration



Observatoire des Sciences et des Technologies (CIRST)

In 1995, BC ranked fourth in terms of the rate of intersectoral collaboration on scientific papers. Quebec ranked first, followed by Ontario; Alberta ranked seventh.

FIGURE 14: Rate of Intersectoral Collaboration



Observatoire des Sciences et des Technologies (CIRST)

Technology Acceptance

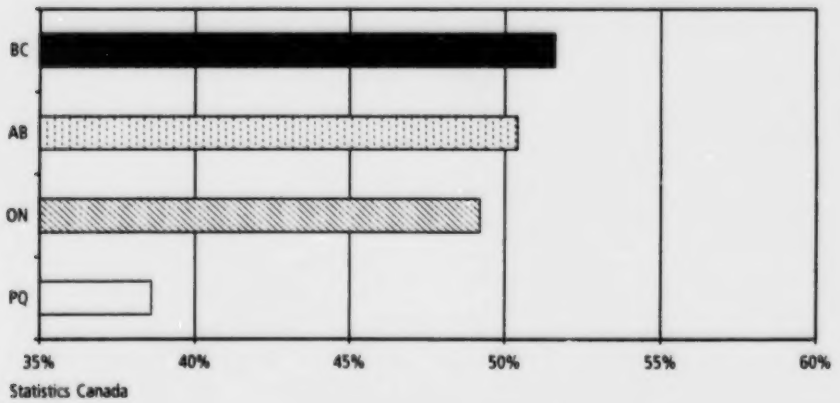
Canadians have been increasingly making use of new information technologies through the 1990s—the number of households with home computers reached 45% in 1998. Throughout the period, BC has led the country with the highest penetration rates of home computer and internet use.

Why are these indicators important?

The rate of technology acceptance is an indicator of the willingness of the population to employ the advantages afforded by high technology. A population highly knowledgeable about computers and the internet is thought to be both a better producer and consumer of high technology products and processes. High technology businesses are attracted to locations where the population tends toward higher rates of technology acceptance.

BC led the country in the percentage of households with home computers in 1998, the last year for which data was available. BC also led the country in 1997. However, the rate of growth of households with home computers was lower than the Canadian average from 1997 to 1998. This is to be expected as the rate of acceptance increases. Whether other provinces will maintain higher growth rates as their percentage of households reaches the same level as in BC remains to be seen.

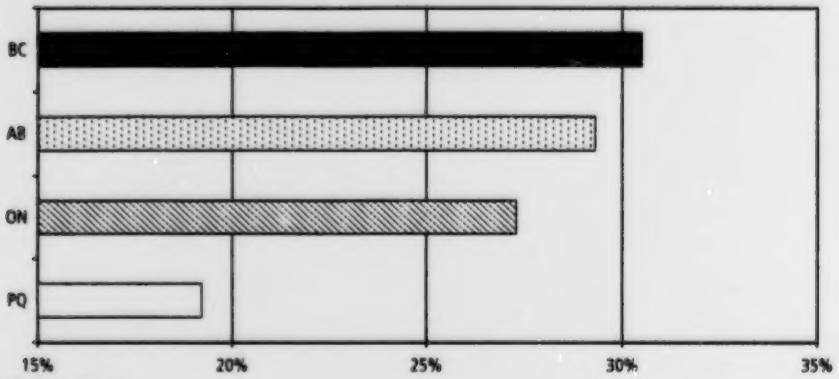
FIGURE 15: Percentage of Households with Home Computers, 1998



Statistics Canada

The story is very similar in the percentage of households using the internet. BC led the country with the highest percentage in both 1998 and 1997. However, the rate of growth for BC was lower from 1997 to 1998 than the Canadian average.

FIGURE 16: Percentage of Households Using the Internet, 1998



Statistics Canada

Technology Licensing

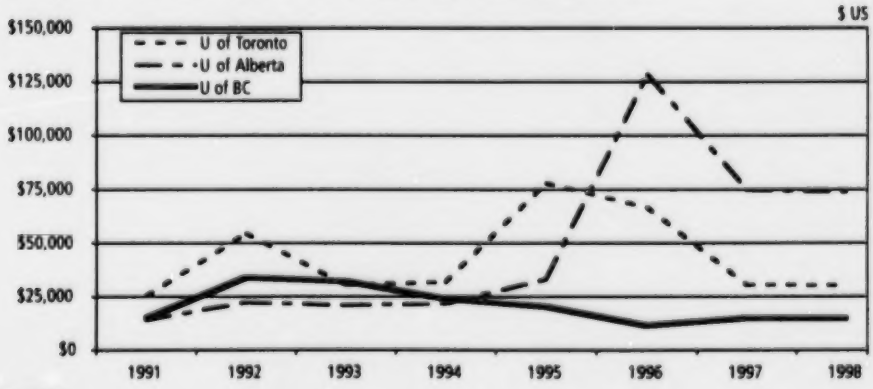
Across Canada, universities began to develop industry liaison offices in the 1980s. The University of Toronto office opened in 1980; UBC's University-Industry Liaison Office (UILO) opened in 1985; the University of Alberta office opened in 1987. These offices work with industry to (among other objectives) spin-off technology developed at the university into successful companies.

Why are these indicators important?

Most universities now require staff to disclose all inventions to the university management. The university then has many options with respect to developing the invention, including licensing the technology to a private company. The average income per license is an indicator of the relative success of the companies at developing and marketing the technology as well as the importance of the original discovery. The number of US patents issued to universities is an important indicator of future revenues.

In 1998, UBC led the Universities of Alberta and Toronto in licenses that produced income but was third out of the three in terms of overall income from those licenses. In fact, the trend over the period of 1991 to 1998 was down in terms of income per technology license for UBC. By contrast, the University of Alberta quintupled its average annual return per license from just under $14,000 US in 1991 to over $73,000 US in 1998.

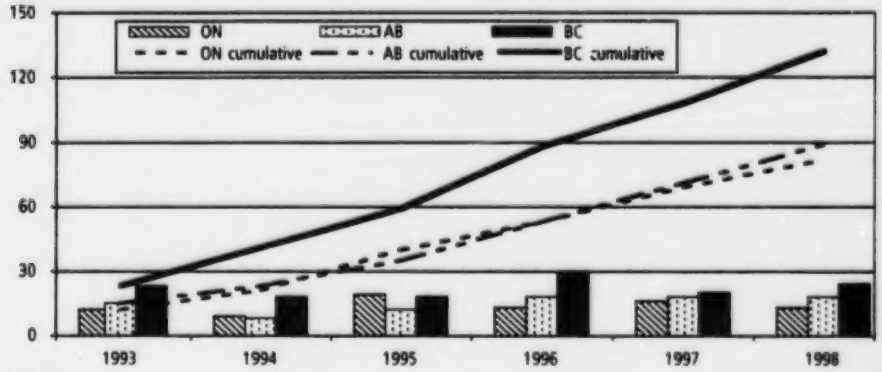
FIGURE 17: Gross Income Per Technology License (in $ US)



BC STATS

BC led Alberta and Ontario every year from 1993 to 1998 in terms of the number of US patents awarded to its top two institutions.[9] Over the period, this opened up a significant cumulative advantage amounting to 43 more patents than Alberta and 50 more than Ontario. In future years, as these patented discoveries are spun-off, this advantage may translate into higher revenues from technology licenses for BC.

FIGURE 18: US Patents Issued to Top Two Institutions, Actual and Cumulative



BC STATS

[9] The University of British Columbia and Simon Fraser University for BC; the Universities of Calgary and Alberta for Alberta; for Ontario, the Universities of Toronto and Waterloo.

Performance of R&D by the Higher Education Sector

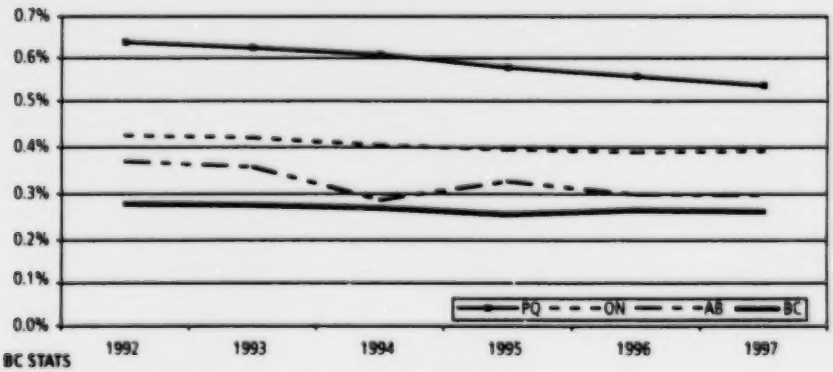
Overall, the higher education sector[10] in Canada performed $3.4 billion worth of research and development (R&D) in 1997. This amounted to nearly 0.4% of Canada's Gross Domestic Product (GDP) in that year. The ratio of R&D performed by the higher education sector to provincial GDP was highest in Quebec at 0.54% in 1997. The other high technology provinces—Ontario, Alberta and BC—were all lower than the Canadian average.

Why is this indicator important?

R&D in universities is important to the economy in two major ways: firstly, academic research is published and available to the entire economy as a resource; secondly, universities increasingly are working in partnership with industry to bring the products and processes of R&D to market (see "Technology Licensing"). The ratio of R&D performed by higher education to GDP is an indicator of the proportional investment in R&D by the higher education sector relative to the size of the overall economy. It is assumed that a higher proportion is likely to lead to higher rates of discovery.

From 1992 to 1997, the Canadian ratio of higher education performance of R&D to GDP declined. The ratio declined as well in the high technology provinces, which were, with the exception of Quebec, all below the Canadian average over the period. BC was eighth overall in Canada, ahead of New Brunswick and Prince Edward Island.

FIGURE 19: Ratio of Higher Education Performance of R&D to GDP



[10] Includes the Private Non-Profit sector which accounts for less than 5% of the total.

Business Indicators

This set of nine indicators is concerned with the stimulus to business formation and growth that comes from internal research and development, patenting, and venture capital. It also measures results that are in part due to these stimuli, in the form of establishment entries and exits, "gazelle" companies, and the overall growth in the number of establishments.

Compared to other Canadian provinces, British Columbia returns average or below average ratings in all of the business stimulus indicators. However, many have long term upward trends and good performance in the latest year. Exceptions are venture capital and business sector research and development. British Columbia business has been unable to attract much more than ten percent of Canadian venture capital funding (although this is roughly in line with our population size). Business sector performance of research and development has also lagged. In 1997, the ratio of research and development performance by business to provincial GDP was over twice as large in Quebec and Ontario as in BC.

FIGURE 20: Quick Summary Report of Indicators for the Business Sector

INDICATOR	Trend	Latest Year	Related to Other Provinces
16. Patents per capita	↓	↑	below average
17. Patent applications per capita	↑	↑	below average
18. Entries and exits into the high technology sector	↑	↑	n/a
19. # of establishments in the high technology sector	↑	↑	n/a
20. # of gazelles (high growth companies)	↑	↑	n/a
21. Venture capital investment	↑	↓	average
22. Venture capital investment: share of Canadian total	→	↓	average
23. Venture capital investment per capita	↑	↓	average
24. Business performance of R&D to GDP ratio	→	→	below average

Patents and Applications

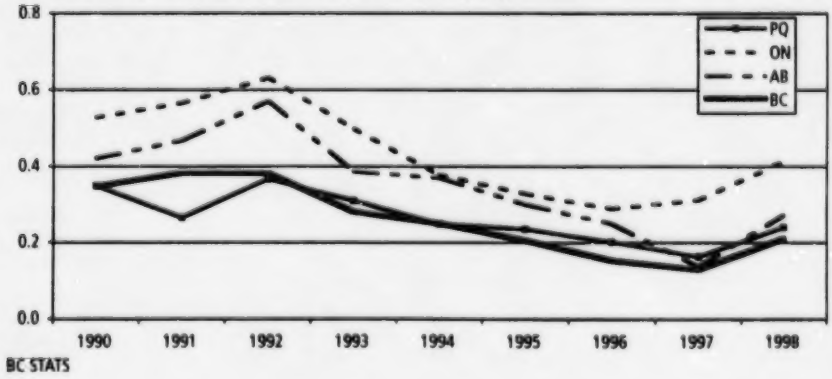
An indicator of the success of research and development, whether in the public or private sector, is the application for and ultimate registration of patents. Through the 1990s, BC lagged the high technology provinces in terms of both patent applications and patents awarded per 10,000 population.

Why are these indicators important?

Patents represent the intellectual capital of innovation. According to the Canadian Intellectual Property Office, "Patents are government grants that give inventors exclusive rights to their inventions....Patents are granted for products or processes that are new, workable and ingenious (novel, useful and inventive). In this way, patents serve as a reward for ingenuity....[Also,] Patents....are an important means of sharing know-how, because each patent document describes a new aspect of a technology in clear and specific terms and is available for anyone to read. Eighteen months after a filing, the document is made public. This is done specifically to promote the sharing of knowledge. Patents are vital resources for businesses, researchers, inventors, academics and others who need to keep abreast of developments in their fields."

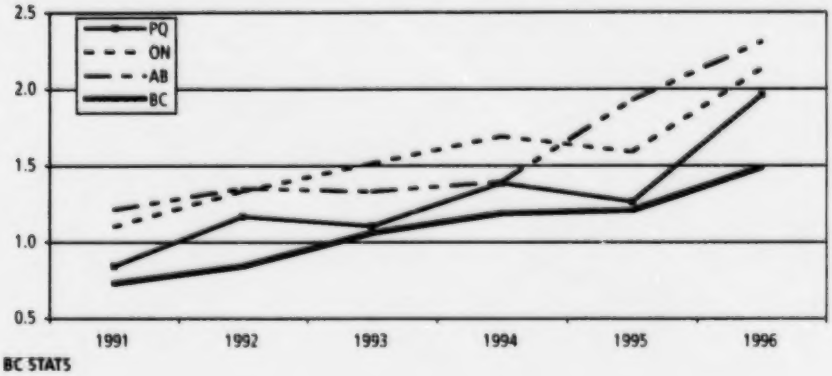
Across Canada, patents awarded per 10,000 population declined from 1992 through 1997 when they began to rebound. Throughout the period 1994 to 1998, BC lagged behind the high technology provinces, reaching a low in 1997 of 0.13 patents awarded per 10,000 population.

FIGURE 21: Patents awarded per 10,000 population



Patent applications are a critical determinant of patents granted, although there is not necessarily a constancy in the number of patents granted per patent application. Patent applications per 10,000 population rose steadily through the early part of the 1990s. BC lagged the high technology provinces through the period 1991 to 1996 while Alberta, which had experienced very little growth in applications in 1992 and 1993, leapt ahead of the leading high technology provinces in 1995.

FIGURE 22: Patents applications per 10,000 population



BC STATS

Sector Dynamism: Entries and Exits

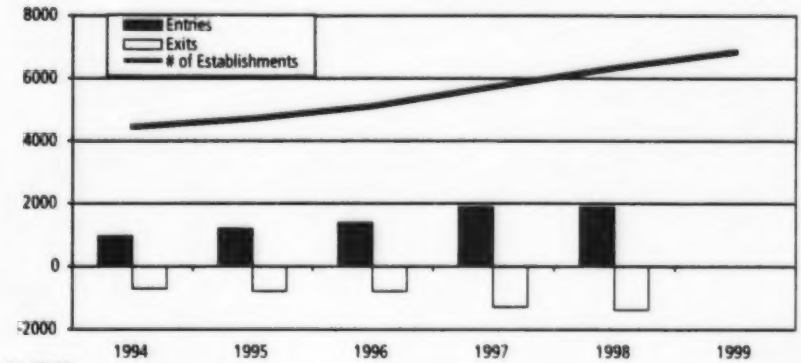
An indicator of the vibrancy of the innovation economy is the number of entries and exits to the high technology sector. BC's high technology sector is characterized by both a high rate of entries and a high rate of exits—sector dynamism peaked in 1997 with an entry rate of 33% and an exit rate of 22%.

Why is this indicator important?

A dynamic sector, characterized by a healthy mixture of large and small, old and new firms, is ideal for generating high levels of innovation. Large, established firms provide employment and earnings stability while small start-ups provide market responsiveness and employment growth. Firms that do not succeed are quickly dissolved or absorbed into other more successful firms. The high technology labour force is combined and recombined with capital and ideas in the drive to generate new goods and services. A stagnant sector, characterized by several large firms and low levels of entry and exit, is not likely to generate high levels of innovation.

Overall, the number of firms in the sector grew at an average annual compound rate of 9.1% in the five years from 1994 to 1999, growing from over 4,400 firms to over 6,800 in that time period. By contrast, the number of firms in the whole BC economy grew at an average annual compound rate of 2.9%. The number of firms in BC's high technology sector grew fairly steadily from 1994 to 1999, indicating that through the 1990s the sector was in a period of significant expansion.

FIGURE 23: Entries and Exits to the BC High Technology Sector



BC STATS

However, the number of entries to the sector leveled off in 1998 while the number of exits continued to grow. It is too early to know if this is the beginning of a trend, but it could suggest that the industry has begun to enter a period of consolidation.

Gazelles: Growth Companies in the High Technology Sector

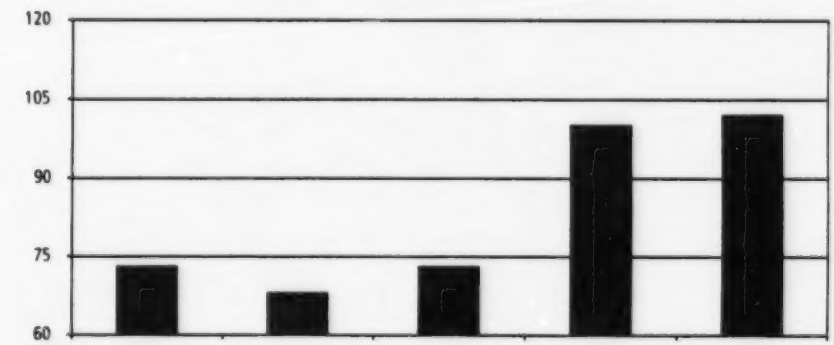
High technology companies exhibiting high levels of growth are indicative of the potential of the high technology sector. A "gazelle"[11] is a company that bounds ahead of others by growing at a very rapid rate. BC showed growth in the number of such companies through the middle period of the 1990s.

Why is this indicator important?

A high level of growth is a strong indicator of the success of the sector. Just as plants grow fastest when conditions are best—lots of light, water and nutrients—so too with firms. It is assumed that a firm cannot grow rapidly without the fundamental elements of growth—access to capital, skilled labour and markets—in place. Also, companies that create large amounts of new employment are the "payback" to the economy of any efforts taken to foster the growth of the sector. An increasing number of high-growth companies creates new jobs, new wealth, and new government revenues.

The number of high-growth companies in the BC high technology sector reached a low of 68 in 1994 and peaked in 1997 at 102. Years prior to 1993 are not available due to methodological change in the source data.

FIGURE 24: Growth Companies in the BC High Technology Sector



BC STATS

[11] "Gazelle" companies are referred to in the 1997 Massachusetts Index as publicly traded companies that have grown at an annual average compound rate of 20% or more for the last four years. According to the Index, this term was coined by David Birch of Cognetics, Inc. BC STATS has devised a methodology to identify high-growth companies in the BC high technology sector that involves counting the number of companies whose employment size increased two categories in a given year. However, as methodologies differ, this number is not currently comparable to other jurisdictions.

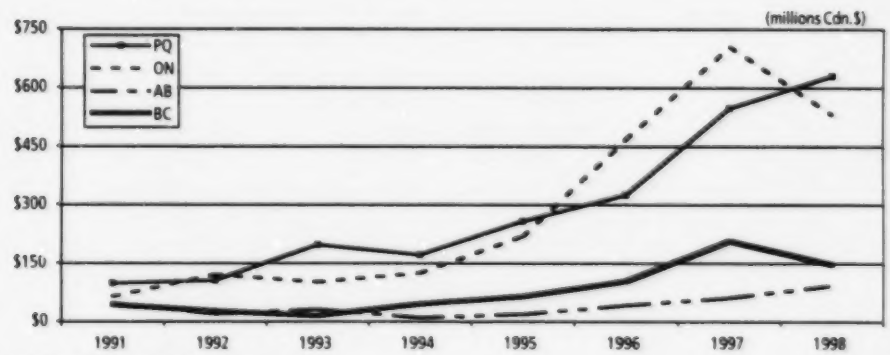
Venture Capital Investment

Through the 1990s, the level of venture capital investment in BC was trending upward though it did decline in 1998, likely due to the Asian economic downturn. However, since 1994, BC's proportion of the total Canadian venture capital investment has hovered between 9% and 11%. The level of venture capital investment per capita reached its peak in BC in 1997 at over $52.

Why are these indicators important?

Venture capitalists—investors who invest in high-risk company start-ups or expansions—are constantly considering whether the reward justifies the risk. Most venture money is lost when the investment does not play out, but those companies that do succeed often have a very large payback. In assessing whether or not a company will succeed, many other conditions aside from the quality of the company itself must be considered, including the business climate in the jurisdiction in which the venture is located. In this way, venture capital investment by province is a good proxy for both the quality of ventures in a given province as well as the venture capitalists' assessment of the business climate.

FIGURE 25: Canadian Venture Capital Investment by Investee Province

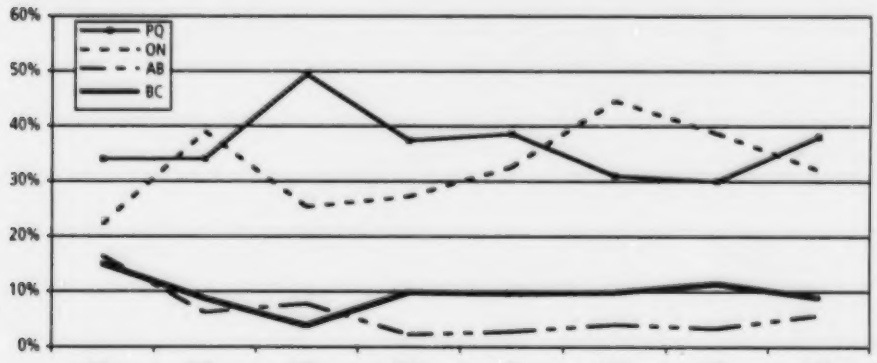


Canadian Venture Capital Association

As the 1990s progressed, Quebec and Ontario became the most successful Canadian provinces in attracting venture capital investment: over the period for which data was collected, each attracted 35% of the total investment. BC was next, attracting 10% of all Canadian venture capital investment from 1991 to 1998. Over the period this amounted to $651 million—twice as much as Alberta's $321 million.

BC's proportional share of total Canadian venture capital investment declined heading into the recession of the early 1990s but rebounded in 1994 and has held steady since. By contrast, Alberta's share reached its low in 1994 and has slowly climbed since but is still one-third lower than BC's. Ontario's share rose and fell dramatically twice over the period and is currently just under a third of the Canadian total.

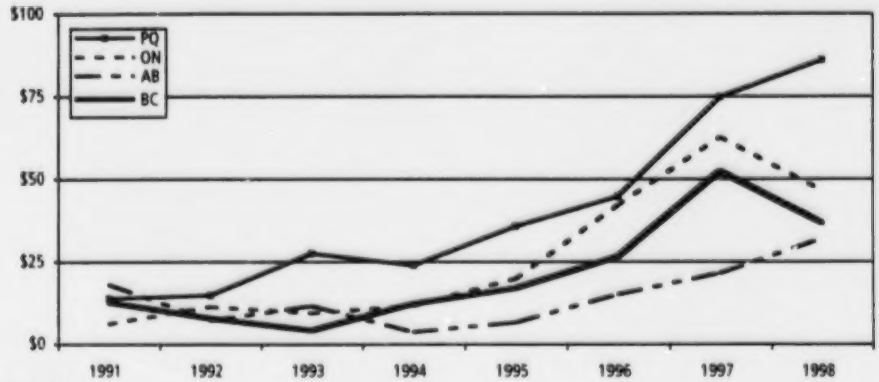
FIGURE 26: Proportional Share of Canadian Venture Capital Investment



Canadian Venture Capital Association

When normalized for population, all the leading high technology provinces were clustered around $13 of venture capital investment per capita in 1991. Alberta was actually the most successful by this measure, obtaining over $18 per capita. By 1998, Alberta trailed the leading high technology provinces, with $32 per capita.

FIGURE 27: Canadian Venture Capital Investment Per Capita



BC STATS

Performance of R&D by the Business Sector

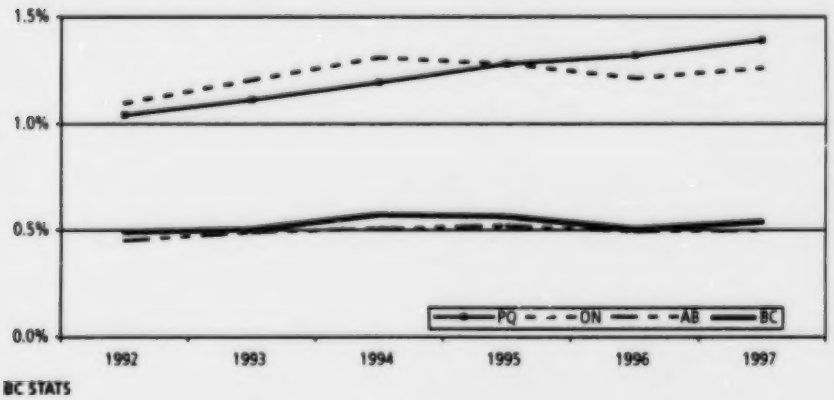
Overall, the business sector in Canada performed $8.5 billion worth of research and development in 1997. This amounted to nearly 1% of Canada's Gross Domestic Product (GDP) in that year. The ratio of R&D performed by the business sector to provincial GDP was much higher than the Canadian average in Quebec and Ontario through the 1990s and much lower in BC and Alberta.

Why is this indicator important?

New products and processes, and the services required to help customers use and maintain new products and processes, are often the outcome of R&D. In this way, R&D is viewed as a reinvestment in the future production of the economy. The ratio of R&D performed by business to GDP is an indicator of the proportional investment in R&D by the business sector relative to the size of the overall economy. It is assumed that a higher proportion is likely to lead to higher rates of discovery.

From 1992 to 1997, the Canadian ratio of business performance of R&D to GDP was entirely driven by Quebec and Ontario, due to the sheer magnitude of the R&D investments by businesses in those provinces. All other provinces, including BC and Alberta, were below the Canadian average. In 1997, the ratio of R&D performance by business to provincial GDP was over twice as large in Quebec and Ontario as in the next closest province, BC.

FIGURE 28: Ratio of Business Performance of R&D to GDP



BC STATS

Government Indicators

The government sector affects high technology firms by providing a regulatory, tax, and infrastructure environment, by funding research and development (R&D), and by directly performing certain R&D. In British Columbia, the tax regime is approximately on a par with other provinces. However, the federal Scientific Research and Experimental Development (SR&ED) tax credit program has not benefited British Columbia in proportion to the size of its economy. Direct performance of R&D by government has similarly lagged in this province.

This section also includes a summary of British Columbia's gross expenditure on R&D (GERD). This is R&D performed by higher education and business, in addition to government.

FIGURE 29: Quick Summary Report of Indicators for the Government Sector

INDICATOR	Trend	Latest Year	Related to Other Provinces
25. Tax index for $80,000 income	↓	↓	average
26. Small business tax rate	↓	↓	below average
27. Corporate tax rate	→	→	above average
28. SR&ED tax credits per capita	↑	↑	below average
29. SR&ED tax credits per capita (small firms)	↑	↓	above average
30. Government performance of R&D to GDP ratio	↓	↓	below average
31. Gross expenditure on R&D (GERD) to GDP ratio	→	→	below average

Tax Rates: Individual and Corporate

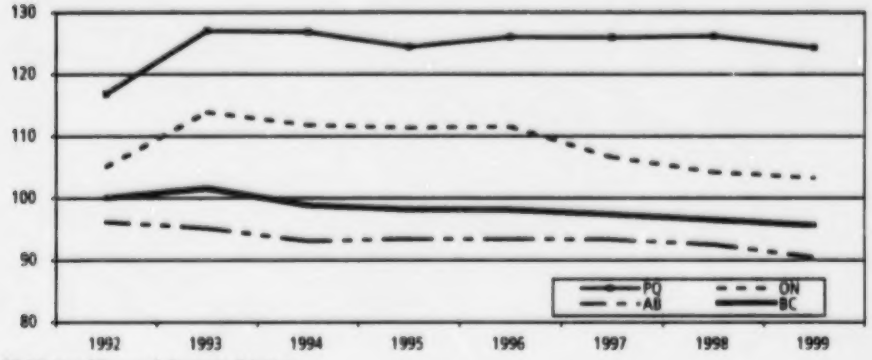
Tax rates are one significant policy area over which the government has complete control. Lower levels of taxation are thought to attract investment and a skilled workforce—both essential to the high technology sector. On the other hand, a better quality of life usually associated with regulation of working conditions, environmental standards, and universal social programs are thought to be attractive to high technology workers—but these generally result in higher levels of taxation. Overall, the level of taxation in BC declined through the 1990s with the exception of the corporate tax rate.

Why are these indicators important?

High technology companies differ significantly from traditional companies insofar as they require neither proximity to raw materials nor proximity to markets. In this way, high technology companies are often free to seek an ideal location. However, they do require proximity to skilled labour, and if that skilled labour is not available locally, they need to be able to attract it. Individual tax rates are seen to be an important determinant in the choice to locate in a given area. Also, small business corporate tax rates are thought to affect the rate at which young companies can grow—the less the government takes in the early years the more that can be reinvested in the company. Corporate tax rates for large companies may also be a major determinant in the choice of location for head offices, regional branches and manufacturing plants.

The level of taxation in BC for high-income single people has declined since its peak in 1993. BC's position relative to Alberta and Ontario has changed little since 1992.

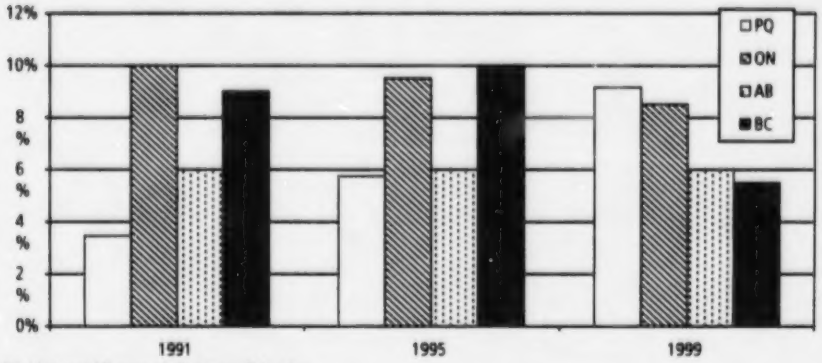
FIGURE 30: Index of All Taxes Paid by Unattached Individuals Earning $80,000 Per Year



BC Ministry of Finance & Corporate Relations

BC's small business tax rate rose in 1995 then declined steeply in 1999 to become the lowest small business tax rate of the leading high technology provinces.

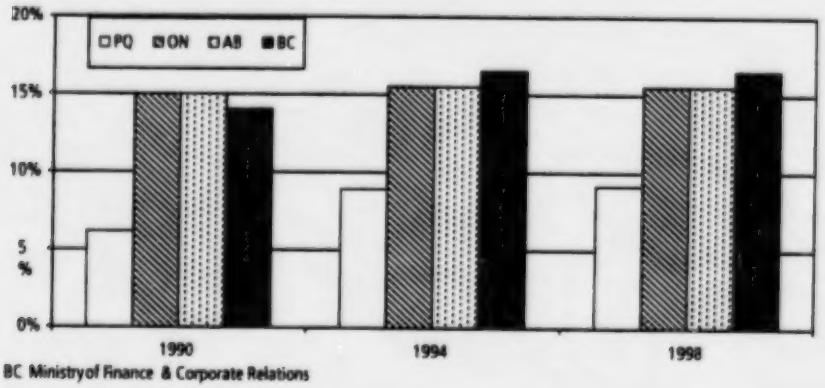
FIGURE 31: Small Business Tax Rate



BC Ministry of Finance & Corporate Relations

BC's corporate tax rate rose in 1991, 1992 and 1993 to its current level. Corporate tax rates in the leading high technology provinces have not changed since 1994.

FIGURE 32: Corporate Tax Rate



BC Ministry of Finance & Corporate Relations

Scientific Research and Experimental Development Tax Credits

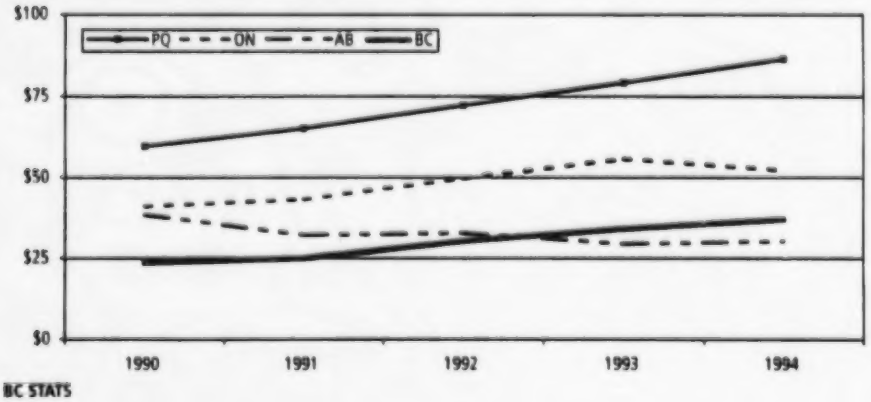
For the five years in the 1990s for which data is available, the overall size of the federal government Scientific Research and Experimental Development (SR&ED) tax credit program increased from $1.06 billion in 1990 to $1.46 billion in 1994. During this time, BC's share of the claims went from over 7% to over 9% of the total.

Why are these indicators important?

The SR&ED tax credit program was established by the federal government in 1986 to provide income tax incentives which would encourage industry to develop technologically advanced products and processes. Corporations with less than $200,000 taxable income can receive a refundable tax credit of up to 35% while most other corporations can receive a credit of up to 20%. The average size of the claims is an important indicator of both the support government is giving to R&D in the private sector and the size of the firms receiving the credits and the scope of their research.

In 1990, BC received the least value of tax credits per capita from SR&ED claims of the high technology provinces. Despite a growing population, BC's per capita value of SR&ED credits received grew in the period 1990 to 1994. The credits received by firms in Ontario and Quebec grew as well, while Alberta's credits received per capita shows a decline for the period.

FIGURE 33: SR&ED Tax Credits Received Per Capita (All Firms)



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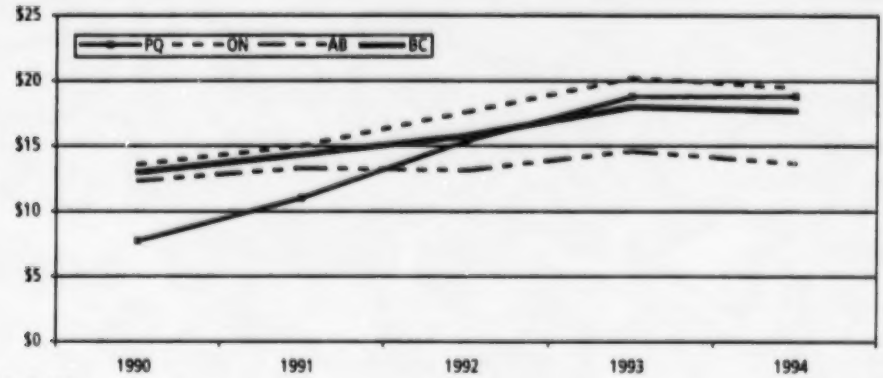
In terms of the value of credits received by smaller firms, BC fares much better, receiving only slightly less per capita than Ontario and Quebec. On a per capita basis, Alberta trailed the leading high technology provinces in 1994.

FIGURE 34: SR&ED Tax Credits Received Per Capita (Small Corporations)



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Performance of R&D by the Government Sector

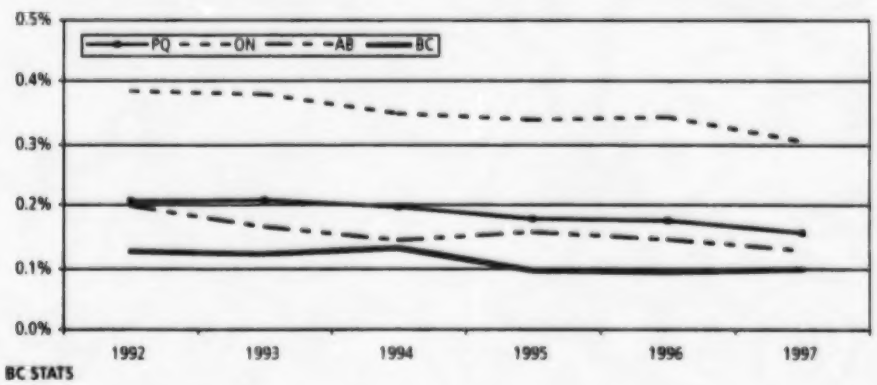
Overall, the government sector in Canada performed $1.92 billion worth of research and development in 1997. This amounted to over 0.2% of Canada's Gross Domestic Product (GDP) in that year. Across Canada, the ratio of R&D performed by the government sector to GDP declined in the 1990s. The ratio in BC was the lowest in the country over the period and was 24% lower in 1997 than in the next closest province—Alberta.

Why is this indicator important?

Government tends to fund much more R&D than it actually performs. However, in some fields, governments do maintain research personnel in order to provide independent testing of products, processes and practices. The purpose of most internal government research is not necessarily focused on innovation, but serves a peer review function. Significant innovations developed by government researchers are often spun-off eventually to the private sector. The ratio of R&D performed by government to GDP is an indicator of the proportional investment in R&D by the government sector relative to the size of the overall economy.

Across Canada, the ratio of combined federal and provincial performance of R&D to GDP steadily declined over the period. BC ranks tenth out of ten provinces in terms of this ratio—BC's ratio was less than half the Canadian average in 1997. This is largely because the BC ratio of federal government performance of R&D to GDP is the lowest in Canada.

FIGURE 35: Ratio of Combined Federal and Provincial Performance of R&D to GDP



Gross Expenditure on R&D

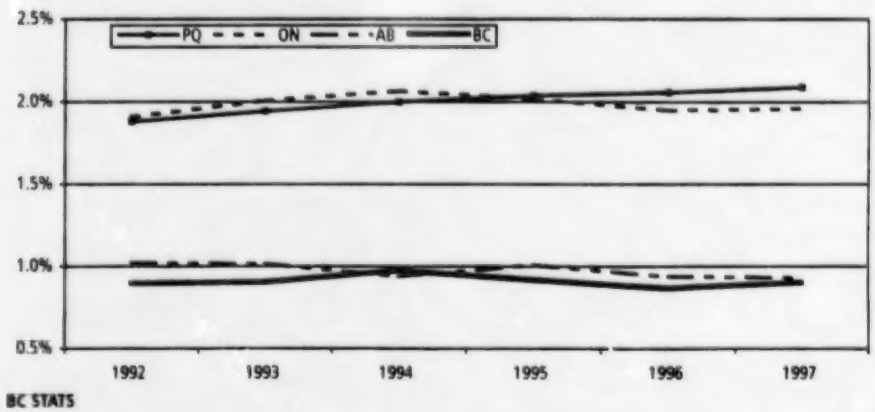
The gross Canadian expenditure on research and development (GERD) was $13.9 billion in 1997, amounting to 1.59% of Canada's Gross Domestic Product (GDP) in that year. Across Canada, the GERD to GDP ratio reached is peak in 1994 at 1.65%. In BC, the ratio in 1997 was 0.9% of provincial GDP, the sixth highest in Canada of the ten provinces.

Why are these indicators important?

The overall ratio of the total R&D effort to the overall economy, also known as the GERD ratio, is a measure of how much a jurisdiction is willing to sacrifice current consumption for increased future capacity. The changing structure of the ratio (the relative size of the component investments by the government, business and higher education sectors) over time is a measure of the shifting importance different sectors place on performance of R&D. The meaningfulness of the GERD ratio has been challenged in recent times. However, the measurement of R&D effort as an indicator for the high technology sector remains a primary objective of national statistical agencies.

Quebec leads the country in terms of the GERD to GDP ratio, followed closely by Ontario at slightly less than 2.0% of GDP annually invested in R&D. The overall Canadian ratio is lower, at 1.6% of GDP. Alberta and BC ranked fifth and sixth respectively, with ratios under 1.0% of GDP annually.

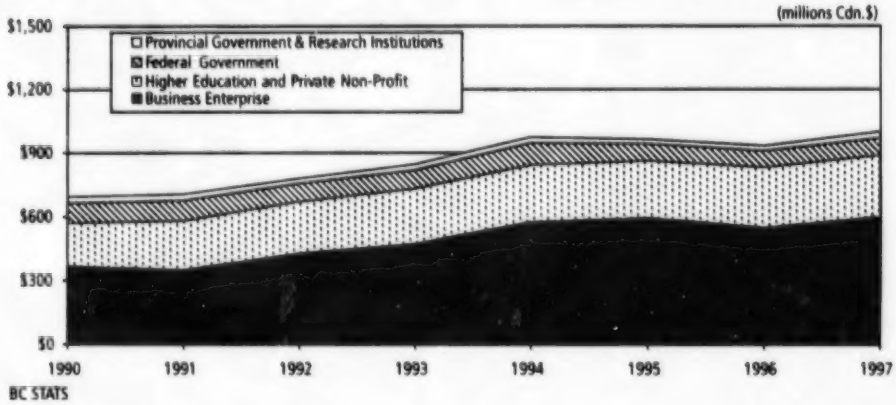
FIGURE 36: Ratio of Total Expenditure on R&D to GDP



The proportion of Ontario's R&D effort performed by the federal government is 15% while the proportion for BC is 8%. In fact, Ontario's federal performance of R&D in 1997 was larger ($1.03 billion) than BC's entire R&D effort ($0.99 billion).

The largest single performer of R&D in BC is the business sector. Business in BC performed 60% of the total R&D effort in 1997, followed by the higher education sector at 29% of BC's total R&D effort. Together, the federal and provincial governments performed just over 10% of BC's 1997 R&D effort.

FIGURE 37: Profile of the BC Total Expenditure on R&D ($ millions)



In BC, less than 10% of GERD is expended on research in the field of the social sciences and humanities; over 90% is expended on research in natural sciences and engineering.

External Indicators

The British Columbia economy is part of a world system that is a source of information, skilled labour, machinery and equipment and other material inputs, as well as markets for locally-produced products. Conversely, British Columbia may lose skilled labour to other jurisdictions or face competition from foreign producers.

Canada, and with it British Columbia, benefits from a large number of well-trained immigrants. The number of such immigrants has increased greatly in recent years, and their level of schooling has increased as well. In relation to its population size, British Columbia is on a par with other provinces in attracting skilled foreigners. As for immigration from other provinces, BC is likely to gain educated and trained workers when there is immigration from other provinces, but since 1998, BC has been experiencing interprovincial outmigration. BC imports of high technology goods, which can be an indicator of future production, dropped in 1996 but have been steadily increasing in the past few years.

FIGURE 38: Quick Summary Report of Indicators for the External Sector

INDICATOR	Trend	Latest Year	Related to Other Provinces
32. Number of immigrants with higher education	↑	↑	average
33. Education level of immigrants	↑	→	average
34. Education & occupation of interprovincial migrants	n/a	n/a	above average
35. Net interprovincial migration	↓	↑	below average
36. High technology imports	↑	↑	n/a

Educational Attainment of Immigrants

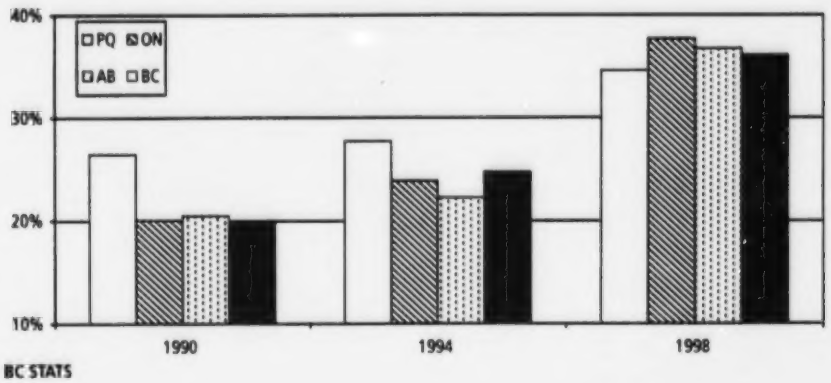
British Columbia experienced heightened levels of immigration in the 1990s. Two indicators of relative levels of educational attainment are the median years of education of immigrants at landing, and the number of immigrants per thousand with 16 or more years of education (sufficient to obtain a university degree in BC) at landing. By these two measures, immigrants to BC, on average, are less well-educated than immigrants to other provinces, particularly the leading high technology provinces. However, in absolute numbers, BC received nearly 66,000 immigrants with 16 or more years of education from 1990 to 1998—more than any other province except Ontario and 20% of the Canadian total for that period.

Why are these indicators important?

While British Columbia can rely on its educational institutions and on-the-job training to provide many skilled workers, some migrate to other provinces or countries. Conversely, critical skilled labour is obtained by British Columbia from external sources. In addition, in the global economy, highly trained immigrants often bring knowledge of other business practices and business opportunities, as well as languages. This firsthand knowledge is vital to those BC companies looking to expand exports or enter new markets.

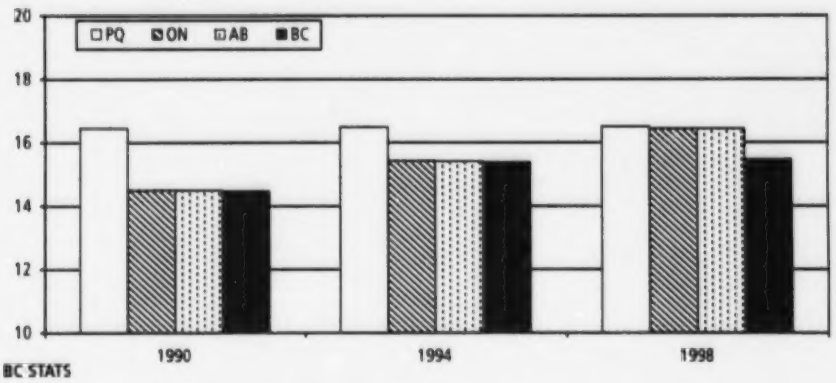
The percentage of immigrants 25 years old and older with 16+ years of education grew dramatically over the period 1990 to 1998. BC and Quebec fared well compared to the leading high technology provinces in the mid 1990s but lost ground to Ontario and Alberta in the late 1990s.

FIGURE 39: Percentage of immigrants per thousand with 16+ years of education



Across the country, the median years of schooling of immigrants 25 years old and older at time of landing increased through the period 1990 to 1998. In 1990, the leading high technology provinces (except Quebec) all trailed the Canadian median. By 1994, these three provinces had caught up to the Canadian median. However, in 1998, BC had not improved over 1994 while the median for the leading high technology provinces and Canada had moved ahead. The median is one full year of education greater in Alberta, Ontario and Quebec than it is in BC.

FIGURE 40: Median years of schooling of immigrants 25 years old and older



Education and Occupation of Interprovincial Migrants

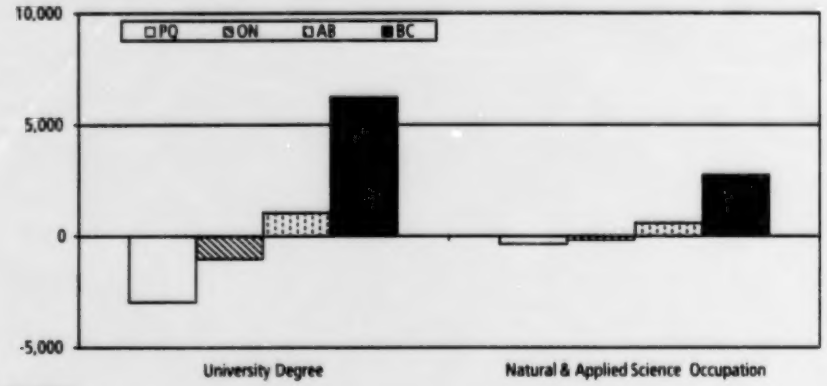
The pattern of interprovincial migration in Canada is largely driven by people seeking better economic opportunity. In the early part of the 1990s, there was a general westward flow of migrants that benefited both BC and Alberta. In 1994, BC had a large net inflow while all other provinces had net outflows. In 1998, the general direction of flow changed, and people began moving east again, mostly to Alberta and Ontario, but also to the Maritime provinces (not including Newfoundland).

Why are these indicators important?

Workers in Canada are much more free to move within the borders of the country than they are internationally. In aggregate, the movements of skilled and educated workers between provinces is a general indicator of both real and perceived economic opportunity. Individuals and families leave when they feel the grass is greener somewhere else. In this way, this indicator points to the overall perception of the strength of provincial economies.

In 1996, BC gained over 6,200 people with university degrees from other provinces in Canada, and over 2,700 people with natural and applied science occupations. Alberta also showed a net gain in both these areas, but a much smaller gain proportionally than BC. Ontario showed a small net loss in both areas while Quebec showed a large net loss of people with university degrees.

FIGURE 41: Net Migration of Potential High Technology Workers, by province, 1996



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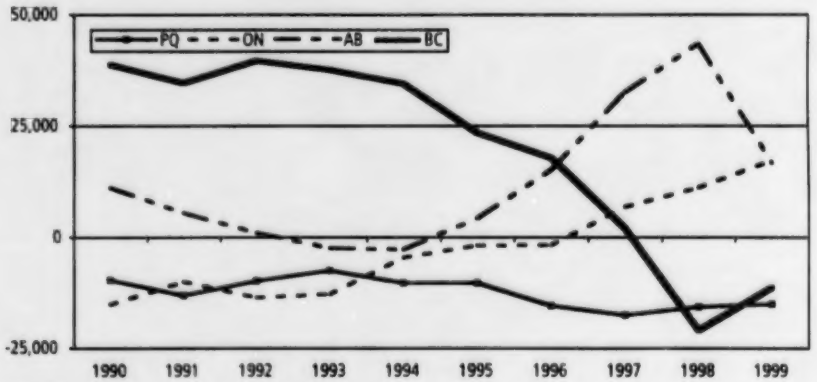
However, 1996 was the last year in which BC showed dramatic net inflows, although by that time BC's net inflow was already down substantially from its high of nearly 40,000 in 1992. In 1997, Ontario began to show a net inflow while Alberta, which had been showing positive immigration since 1995, grew substantially. This trend continued for the last two years of the 1990s. BC showed net outmigration in both 1998 and 1999, while Alberta and Ontario both gained. Quebec, by contrast, lost between 7,000 and 18,000 people every year through the 1990s. This has likely resulted in a significant loss of skilled and educated workers from Quebec.

FIGURE 42: Net Interprovincial Migration, by province, by year



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High Technology Imports

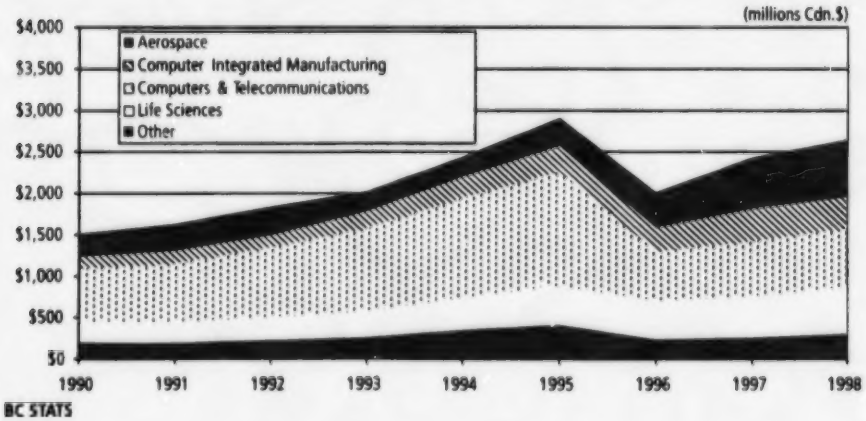
BC's high technology sector is reliant on imports of high technology goods in order to thrive. Imports of high technology goods peaked in 1995 at $2.9 billion then declined sharply in 1996 to $2.0 billion. By 1998, despite a weak Canadian dollar, imports had risen again to $2.6 billion.

Why is this indicator important?

Although a heavy reliance on imports can create a negative trade balance (the difference between the value of goods exported and the value imported), imports of high technology goods are often essential in order to generate future exports of both goods and services. For instance, without state-of-the-art telecommunications, the high technology sector as a whole will struggle. Similarly, purchases of computer integrated manufacturing technology will displace future imports of other goods, whether high technology or low technology goods, and possibly will generate goods for export.

Through 1995, imports of computers and telecommunications products represented over 40% of all high technology imports to the province. However, in 1996, the unadjusted value of these imports fell 56%, from nearly $1.4 billion to $0.6 billion. Since then, computers and telecommunications products have represented less than 30% of all high technology imports. Since 1990, imports of aerospace and life sciences products have increased dramatically, posting gains of 38% and 123% respectively.

FIGURE 43: Value of High Technology Imports to BC by Commodity Type ($ millions)



Labour Indicators

Most of the indicators in this report are grouped according to the sector that provides or affects the input. However, in the case of the labour input, indicators such as the unemployment rate are not attributable to a single source sector. This section contains a set of indicators that are specific to the labour market but represent a combined impact of the source sectors. Overall, BC's high technology employment grew rapidly in the 1990s, but lagged behind the high technology provinces as a percentage of overall employment. In 1995, BC's research workforce was the smallest per capita among the high technology provinces.

Unemployment rates among workers in the natural and applied sciences are well under half of those in the economy overall. Further, these unemployment rates have been falling quite consistently since early in the decade. Corresponding wage rates in the high technology sector are significantly above those in the other sectors, both for workers in high knowledge as well as other occupations required in the sector.

FIGURE 44: Quick Summary Report of Indicators for the Labour Sector

INDICATOR	Trend	Latest Year	Related to Other Provinces
37. Unemployment rate for natural and applied sciences	↓	↓	average
38. Ratio of unemployment rate for natural and applied sciences to the unemployment rate for all occupations	↓	↓	average
39. Income premium in the high technology occupations	→	n/a	below average
40. Income premium in the high technology industries	↓	n/a	below average
41. High technology employment	↑	↑	below average
42. Research personnel per capita	n/a	n/a	below average

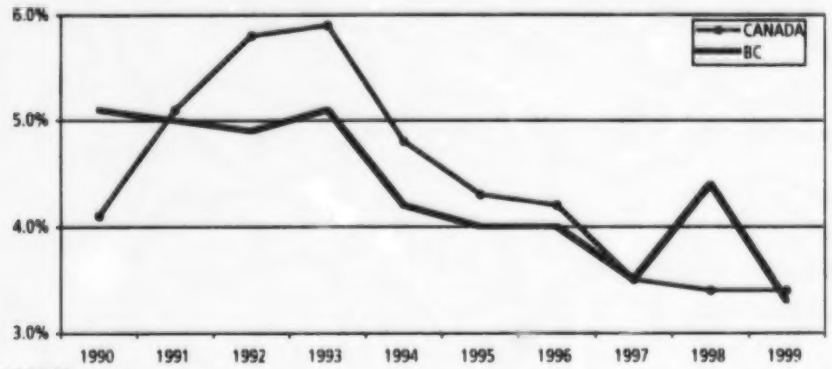
Rate of Unemployment in Natural and Applied Sciences

BC's highest annual rate of unemployment in the 1990s for all occupations occurred in 1992 at 10.2%. Across Canada, the highest annual rate reached was 11.4% in 1993. Persons employed in the natural and applied sciences occupations have enjoyed an employment advantage compared to the entire labour force, with typically lower unemployment rates. Across Canada, the ratio between the unemployment rate in the natural and applied sciences and the entire labour force has been trending downward. In BC, the ratio reached its lowest level of the 1990s in 1999 at 40% of the unemployment rate for all occupations. Last year also marked the lowest actual rate of unemployment for natural and applied science occupations in the 1990s: 3.3%.

Why are these indicators important?

A low level of unemployment in natural and applied sciences occupations is desirable because some components of this group (e.g. computer scientists) are the engines of innovation in the high technology economy. Higher levels of unemployment in this group indicates idle intellectual capital which has the effect of slowing the overall rate of innovation. Also, a lower ratio between the unemployment rate for natural and applied science occupations and the overall labour force indicates heightened demand for these specializations. This should attract high-tech workers from other jurisdictions as well as more students into these areas of specialization.

FIGURE 45: Unemployment Rate for Natural and Applied Sciences Occupations



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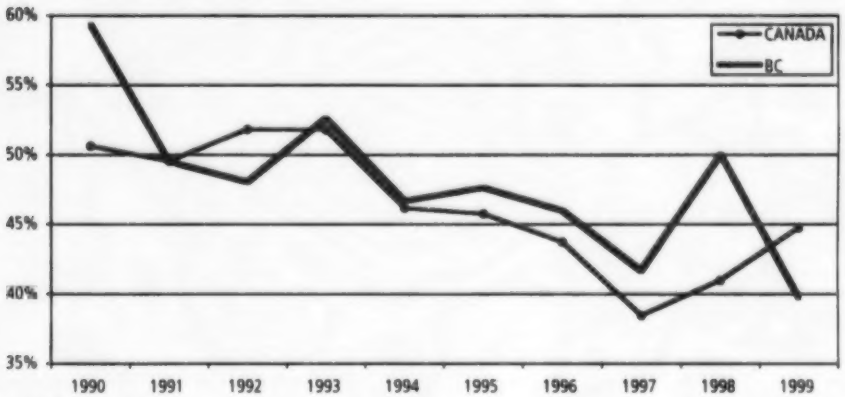
The BC unemployment rate for natural and applied sciences occupations reached its lowest point in the past decade in 1999 after spiking in 1998, likely due to the "Asian flu." Throughout most of the 1990s, BC had a lower rate of unemployment for natural and applied sciences occupations than the Canadian average.

FIGURE 46: Ratio of Unemployment Rates: Natural and Applied Science Occupations to Total Labour Force



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The BC ratio of the unemployment rates for natural and applied sciences occupations to the total labour force also reached its lowest point in the past decade in 1999. However, though currently lower in BC than Canada-wide, the reverse was true for most of the 1990s. Through the 1990s, there was an overall trend downward for the ratio, indicating an increasing advantage in employment to persons with specialization in the natural and applied sciences.

Income Premium in the High Technology Occupations

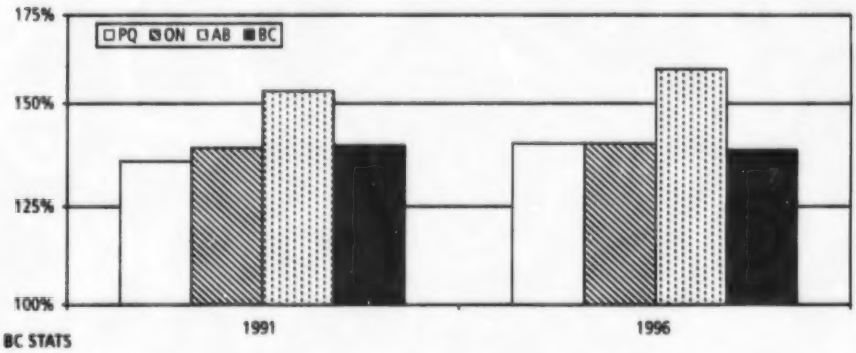
Across Canada, the income of workers in high technology occupations[12] was over 40% higher than that of workers in the overall economy in the early 1990s. From 1991 to 1996, the income premium for high technology occupations grew 4.5%.

Why is this indicator important?

One of the greatest drags on the innovation economy is the scarcity of high technology workers. Higher incomes for these workers relative to other jurisdictions eventually result in higher numbers of workers, leading to higher levels of innovation. As well as attracting workers from other jurisdictions, higher incomes for high technology occupations throughout the economy serve to attract more students into educational paths leading to high technology employment. On the whole, higher incomes indicate the productivity and growth of employer firms, creating a strong labour market. However, high incomes are not the whole story—the cost of living (including taxation), as well as the quality of life in a given jurisdiction also have an effect on the overall level of compensation offered by firms to attract the most highly skilled workforce.

In 1991, the premium for working in high technology occupations was greatest in Alberta. Five years later, the premium in both BC and Ontario had not changed while in Alberta, the premium had risen 3.5%, widening the premium gap between Alberta and the other high technology provinces to nearly 20 percentage points.

FIGURE 47: Ratio of Income for High Technology Occupations to All Occupations



[12] Includes workers in both high and "low" technology industries.

Income Premium in the High Technology Industries

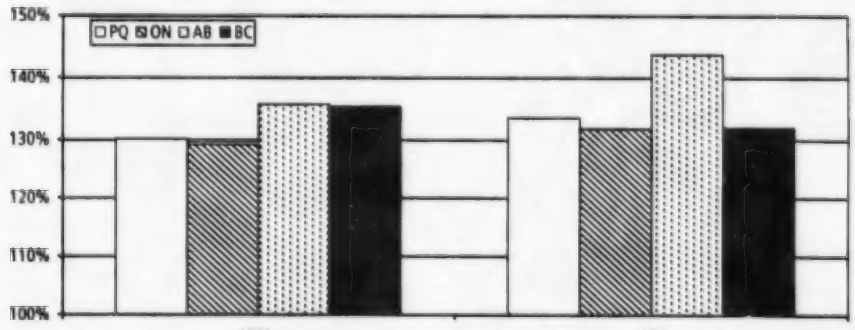
Across Canada, the income of workers in high technology industries[13] was over 30% higher than that of workers in the overall economy in the early 1990s. From 1991 to 1996, the income premium for workers in high technology industries grew 7.5%.

Why is this indicator important?

Many of the reasons that make income in the high technology occupations an important indicator apply equally to income in the high technology industries. However, high technology industries do not employ only high technology workers—there are also "low" technology workers in the high technology industries. These workers may be more skilled on average than their "low" technology counterparts in the "low" technology industries, but they are often still from traditional occupations, such as bookkeeping, office assistance, etc. Higher incomes for workers in the high technology industries indicate that "low" technology workers are also benefiting from the growth and productivity of the employer firms in the high technology sector.

In 1991, the premium for working in high technology industries in BC was comparable to the premium in Alberta and higher than the Canadian average. By 1996, BC's premium had declined 3% while Alberta's had risen 6%, widening the gap in the premiums to nearly 12 percentage points.

FIGURE 48: Ratio of Income for High Technology Industries to All Industries



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[13] Includes workers in both high and "low" technology occupations.

High Technology Employment

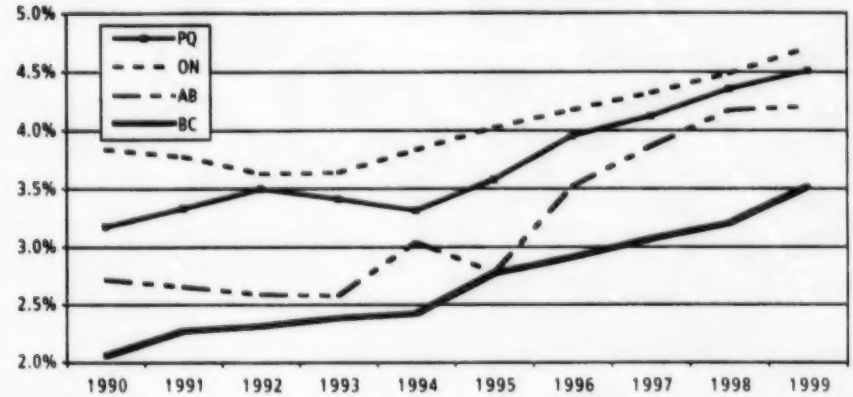
Over the course of the 1990s, employment in the high technology sector grew from 3.0% of Canadian employment to 4.1%, an increase of 39.6%. This showed the high tech sector to be one of the most dynamic growth sectors of the past decade. By comparison, overall Canadian employment grew 4.0% in the same period.

Why is this indicator important?

The diversification of the economy is widely regarded as an important development of the past ten years. It has long been recognized by government that the traditional Canadian dependence upon resource industries—"hewers of wood and drawers of water"—has to change if Canada is to keep its pace as one of the world's economic powers. In BC in particular, there has been much discussion about diversifying the economy to be less dependent upon resource industries. Some "new" sectors, such as tourism and high technology, have been held up as examples of ways to diversify the economy. However, weekly wages in the tourism sector are below the average weekly wages of all industries. By contrast, weekly wages in the high technology sector are considerably above the industrial average.

Over the course of the 1990s, BC's high technology sector employment grew at an average annual compound rate of 7.9%, the highest growth rate of all Canadian provinces and more than double the Canadian rate. However, by the end of the decade, BC's high technology sector employment was still a smaller component of BC's overall employment than in the other leading high technology provinces.

FIGURE 49: High Technology Employment to Total Employment



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Research Personnel

In 1995, BC significantly trailed the high technology provinces and the Canadian average in terms of researchers per 100,000 population. In fact, BC ranked eighth nationally ahead of New Brunswick and PEI in terms of research workforce per 100,000 population. Also, the structure of BC's research workforce differs significantly from that of the rest of the country. BC had the smallest per capita federal government research workforce of any province (35% of the Canadian average). BC's provincial government research workforce is the second smallest on a per capita basis (53% of the Canadian average).

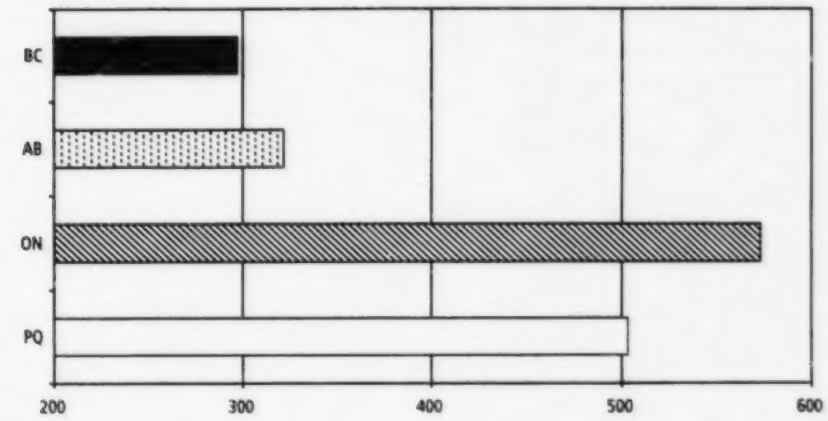
Why are these indicators important?

The absolute number of researchers and technicians engaged in research is an important determinant to the volume of scientific and technical discoveries which may result in patent applications, and later, in the birth of new firms or the growth of existing firms. Also important is the structure of the research workforce in terms of the sector of employment, whether federal government, provincial government, business enterprise or higher education. This is because each sector has different reasons for developing new technology and different methods of bringing new discoveries to market.

British Columbia's workforce of researchers and technicians was the third smallest per capita across Canada in 1995. Ontario, with its large[14] federal government research workforce located in the National Capital Region (Ottawa) has the largest research workforce per capita and the largest in absolute numbers. Alberta had a relatively small federal workforce per capita, but had the highest provincial government research workforce per capita. Overall, Alberta's research workforce ranked 6th across the country in terms of size in 1995.

[14] Ontario's federal government workforce alone is 79% of BC's entire research workforce.

FIGURE 50: Research Workforce per 100,000 population, 1995



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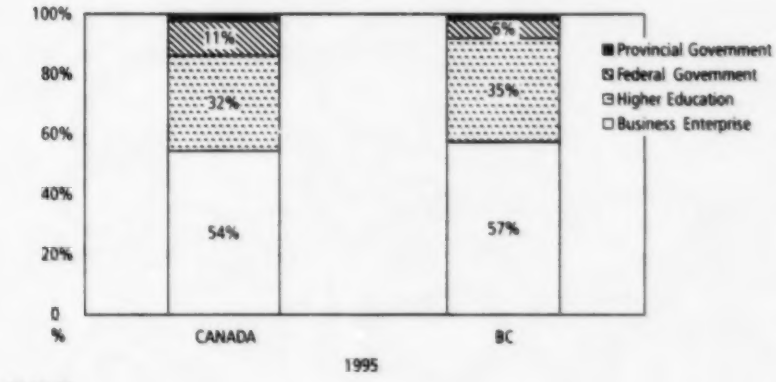
Business enterprises accounted for a similar proportion of the research workforce both in BC and Canada-wide in 1995. However, as mentioned previously, BC's federal government research workforce makes up far less of BC's overall research workforce than in most other Canadian provinces. In BC, as in Canada, the higher education research workforce is the second largest proportion but is larger in BC than the Canadian average. Canada-wide, only a small proportion of the overall research workforce worked in the provincial government sector in 1995.

FIGURE 51: Structure of Research Workforce by Sector, Canada and BC, 1995



BC STATS

Final Words: Indicators Research is in Progress

BC STATS has taken its lead from those who have gone before. The indicators chosen for this report have been chosen from a list of all known indicators that have been used in the field. These were then subject to a set of criteria similar to those used by the Massachusetts Collaborative with one crucial addition: availability. Any indicators requiring data not currently available could not be included. In the future, new data may become available either from administrative sources or the development of new survey tools, either by Statistics Canada, BC STATS, or others.

The model of the indicators and how they are believed to relate to changes in output of the high-tech sector is a work in progress. The existence of the links, the strength of the relationships, even the lag between when a change observed in the input indicator will generate a change in an output indicator—none of these is proven. However, this report has presented the results of an extensive data collection effort which will support future attempts to model the high technology sector's interactions with other institutions.